

***Campbell Biology in Focus (Urry)***  
**Chapter 2 The Chemical Context of Life**

2.1 Multiple-Choice Questions

1) About 25 of the 92 natural elements are known to be essential to life. Which 4 of these 25 elements make up approximately 96% of living matter?

- A) carbon, sodium, hydrogen, nitrogen
- B) carbon, oxygen, phosphorus, hydrogen
- C) oxygen, hydrogen, calcium, nitrogen
- D) carbon, hydrogen, nitrogen, oxygen
- E) carbon, oxygen, nitrogen, calcium

Answer: D

Topic: Concept 2.1

Skill: Knowledge/Comprehension

Learning Outcome: 2.1

2) Trace elements are those required by an organism in only minute quantities. Which of the following is a trace element that is required by humans and other vertebrates, but not by other organisms such as bacteria or plants?

- A) nitrogen
- B) calcium
- C) iodine
- D) sodium
- E) phosphorus

Answer: C

Topic: Concept 2.1

Skill: Knowledge/Comprehension

Learning Outcome: 2.1

3) Which of the following statements is *false*?

- A) Carbon, hydrogen, oxygen, and nitrogen are the most abundant elements of living matter.
- B) Some naturally occurring elements are toxic to organisms.
- C) All organisms require the same elements in the same quantities.
- D) Iron is an example of an element needed by all organisms.
- E) Approximately one-quarter of the natural elements are essential elements.

Answer: C

Topic: Concept 2.1

Skill: Application/Analysis

Learning Outcome: 2.1

4) Why is each element unique and different from other elements with respect to its chemical properties?

- A) Each element has a unique atomic mass.
- B) Each element has a unique atomic number.
- C) Each element has a unique number of protons.
- D) Each element has a unique number of neutrons.
- E) Each element has different radioactive properties.

Answer: C

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

5) Knowing just the atomic mass of an element allows inferences about which of the following?

- A) the number of electrons in the element
- B) the number of protons in the element
- C) the number of neutrons in the element
- D) the number of protons plus neutrons in the element
- E) the number of protons plus electrons in the element

Answer: D

Topic: Concept 2.2

Skill: Application/Analysis

Learning Outcome: 2.2

6) In what way are elements in the same column of the periodic table the same?

- A) They have the same number of protons.
- B) They have the same number of neutrons.
- C) They have the same number of electrons.
- D) They have the same number of electrons in their valence shell.
- E) They have the same number of electron shells.

Answer: D

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

7) The nucleus of a nitrogen atom contains 7 neutrons and 7 protons. Which of the following is a correct statement concerning nitrogen?

- A) The nitrogen atom has a mass number of approximately 7 and an atomic number of 14.
- B) The nitrogen atom has a mass number of approximately 14 and an atomic number of 7.
- C) The nitrogen atom has a mass number of approximately 14 and an atomic number of 14.
- D) The nitrogen atom has a mass number of approximately 7 and an atomic number of 21.
- E) The nitrogen atom has a mass number of approximately 14 and an atomic number of 21

Answer: B

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

8) Molybdenum has an atomic number of 42. Several common isotopes exist, with mass numbers of 92, 94, 95, 96, 97, 98, and 100. Therefore, which of the following can be true?

- A) Molybdenum atoms can have between 50 and 58 neutrons.
- B) The isotopes of molybdenum have different electron configurations.
- C) The isotopes of molybdenum can have between 50 and 58 protons.
- D) The isotopes of molybdenum have between 50 and 58 neutrons and have different electron configurations.
- E) The isotopes of molybdenum have between 50 and 58 protons and have different electron configurations.

Answer: A

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

9) Carbon-12 is the most common isotope of carbon and has a mass number of 12. However, the atomic mass of carbon is slightly more than 12 daltons. Why?

- A) The atomic mass does not include the mass of electrons.
- B) Some carbon atoms in nature have an extra proton.
- C) Some carbon atoms in nature have more neutrons.
- D) Some carbon atoms in nature have a different valence electron distribution.
- E) Some carbon atoms in nature have undergone radioactive decay.

Answer: C

Topic: Concept 2.2

Skill: Application/Analysis

Learning Outcome: 2.2

10) One difference between carbon-12 ( ${}^{12}_6\text{C}$ ) and carbon-14 ( ${}^{14}_6\text{C}$ ) is that carbon-14 has

- A) two more protons than carbon-12.
- B) two more electrons than carbon-12.
- C) two more neutrons than carbon-12.
- D) two more protons and two more neutrons than carbon-12.
- E) two more electrons and two more neutrons than carbon-12.

Answer: C

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

11) An atom has 6 electrons in its outer shell. How many unpaired electrons does it have?

- A) 0
- B) 2
- C) 4
- D) 6
- E) 2 or 4

Answer: B

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

12) The atomic number of nitrogen is 7. Nitrogen-15 is heavier than nitrogen-14 because the atomic nucleus of nitrogen-15 contains how many neutrons?

- A) 6
- B) 7
- C) 8
- D) 12
- E) 14

Answer: C

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

13) Electrons exist only at fixed levels of potential energy. However, if an atom absorbs sufficient energy, a possible result is that

- A) an electron may move to an electron shell farther away from the nucleus.
- B) an electron may move to an electron shell closer to the nucleus.
- C) the atom may become a radioactive isotope.
- D) the atom would become a positively charged ion, or cation, and become a radioactive isotope.
- E) the atom would become a negatively charged ion, or anion.

Answer: A

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

14) The atomic number of neon is 10. Therefore, which of the following is most correct about an atom of neon?

- A) It has 8 electrons in its outer electron shell.
- B) It is inert.
- C) It has an atomic mass of 10 daltons.
- D) It has 8 electrons in its outer electron shell and it is inert.
- E) It has 8 electrons in its outer electron shell, it is inert, and it has an atomic mass of 10 daltons.

Answer: D

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

15) From its atomic number of 15, it is possible to predict that the phosphorus atom has

- A) 15 neutrons.
- B) 15 protons.
- C) 15 electrons.
- D) 8 electrons in its outermost electron shell.
- E) 15 protons and 15 electrons.

Answer: E

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

16) The atomic number of each atom is given to the left of each of the following elements.

Which of the atoms has the same valence as carbon ( ${}_{6}^{12}\text{C}$ )?

- A)  ${}_{7}^{\text{N}}$  nitrogen
- B)  ${}_{9}^{\text{F}}$  fluorine
- C)  ${}_{10}^{\text{Ne}}$  neon
- D)  ${}_{12}^{\text{Mg}}$  magnesium
- E)  ${}_{14}^{\text{Si}}$  silicon

Answer: E

Topic: Concept 2.2

Skill: Application/Analysis

Learning Outcome: 2.2

17) Two atoms appear to have the same mass number. These atoms

- A) must have the same atomic number.
- B) must have the same number of electrons.
- C) must have the same chemical properties.
- D) must have the same number of protons + neutrons.
- E) must have the same atomic number, the same number of protons + neutrons, the same number of electrons, and the same chemical properties.

Answer: D

Topic: Concept 2.2

Skill: Synthesis/Evaluation

Learning Outcome: 2.2

18) Phosphorus-32, a radioactive isotope of phosphorus-31 (atomic number 15), undergoes a form of radioactive decay whereby a neutron turns into a proton, which is retained in the nucleus, and emits radiation in the form of an electron. What is the product of such radioactive decay of phosphorus-32?

- A) phosphorus-31
- B) a positively charged phosphorus-31 ion
- C) a negatively charged phosphorus-32 ion
- D) sulfur-32 (atomic number 16)
- E) the conversion of the phosphorus-32 atom into pure energy

Answer: D

Topic: Concept 2.2

Skill: Application/Analysis

Learning Outcome: 2.2

19) Fluorine has an atomic number of 9 and a mass number of 19. How many electrons are needed to complete the valence shell of a fluorine atom?

- A) 1
- B) 3
- C) 0
- D) 7
- E) 9

Answer: A

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

20) Oxygen has an atomic number of 8 and a mass number of 16. Thus, what is the atomic mass of an oxygen atom?

- A) approximately 8 grams
- B) approximately 8 daltons
- C) approximately 16 grams
- D) approximately 16 daltons
- E) approximately 24 grams

Answer: D

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

21) What is the maximum number of electrons in a single  $2p$  orbital of an atom?

- A) 1
- B) 2
- C) 3
- D) 4
- E) 5

Answer: B

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

22) An atom with atomic number 12 would have what type of chemical behavior in bonding with other elements?

- A) It would form ions with a +1 charge.
- B) It would form ions with a +2 charge.
- C) It would form ions with a -1 charge.
- D) It would form ions with a -2 charge.
- E) It would form two covalent bonds with other atoms.

Answer: B

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3

23) A covalent chemical bond is one in which

- A) electrons are removed from one atom and transferred to another atom so that the two atoms become oppositely charged.
- B) protons and neutrons are shared by two atoms so as to satisfy the requirements of both atoms.
- C) outer-shell electrons of two atoms are shared so as to satisfactorily fill the outer electron shells of both atoms.
- D) outer-shell electrons of one atom are transferred to fill the inner electron shell of another atom.
- E) an electron occupies a hybrid orbital located between the nuclei of two atoms.

Answer: C

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3

24) If an atom of sulfur (atomic number 16) were allowed to react with atoms of hydrogen (atomic number 1), which of the following molecules would be formed?

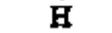
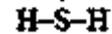
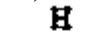
A) S–H

B) H–S–H

C)



D)



E) H = S = H

Answer: B

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3

25) What is the maximum number of covalent bonds an element with atomic number 8 can make with hydrogen?

A) 1

B) 2

C) 3

D) 4

E) 6

Answer: B

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3

26) Nitrogen (N) is much more electronegative than hydrogen (H). Which of the following statements is correct about the atoms in ammonia (NH<sub>3</sub>)?

- A) Each hydrogen atom has a partial positive charge; the nitrogen atom has a partial negative charge.
- B) The nitrogen atom has a full positive charge; each hydrogen atom has a full positive charge.
- C) Each hydrogen atom has a partial negative charge; the nitrogen atom has a full positive charge.
- D) The nitrogen atom has a partial positive charge; each hydrogen atom has a partial negative charge.
- E) There are covalent bonds between the hydrogen atoms and polar bonds between each hydrogen atom and the nitrogen atom.

Answer: A

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3

27) When two atoms are equally electronegative, they will interact to form

- A) hydrogen bonds.
- B) van der Waals interactions.
- C) polar covalent bonds.
- D) nonpolar covalent bonds.
- E) ionic bonds.

Answer: D

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3

28) What results from an unequal sharing of electrons between atoms?

- A) a nonpolar covalent bond
- B) a polar covalent bond
- C) an ionic bond
- D) radioactive decay
- E) a hydrophobic interaction

Answer: B

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3

- 29) A covalent bond is likely to be polar when
- A) one of the atoms sharing electrons is much more electronegative than the other atom.
  - B) the two atoms sharing electrons are equally electronegative.
  - C) oxygen is one of the two atoms sharing electrons.
  - D) one of the atoms has absorbed more energy than the other atom.
  - E) the two atoms sharing electrons are different elements.

Answer: A

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3

- 30) Which of the following molecules contains the most polar covalent bond?

- A) H<sub>2</sub>
- B) O<sub>2</sub>
- C) CO<sub>2</sub>
- D) H<sub>2</sub>O
- E) CH<sub>4</sub>

Answer: D

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3

- 31) In comparing covalent bonds and ionic bonds, which of the following would you expect?

- A) An atom can form covalent bonds with multiple partner atoms, but only a single ionic bond with a single partner atom.
- B) Covalent bonds and ionic bonds occupy opposite ends of a continuous spectrum, from nearly equal to completely unequal sharing of electrons.
- C) Both involve electrical attraction between the electrons of one atom and the nucleus of the other atom.
- D) Ionic interactions remain when covalent bonds are broken in water. Ionic bonds are much stronger than covalent bonds.

Answer: B

Topic: Concept 2.3

Skill: Synthesis/Evaluation

Learning Outcome: 2.3

32) What is the difference between covalent bonds and ionic bonds?

- A) Covalent bonds are formed between atoms to form molecules; ionic bonds are formed between atoms to form compounds.
- B) Covalent bonds involve the sharing of pairs of electrons between atoms; ionic bonds involve the sharing of single electrons between atoms.
- C) Covalent bonds involve the sharing of electrons between atoms; ionic bonds involve the electrical attraction between atoms.
- D) Covalent bonds involve the sharing of electrons between atoms; ionic bonds involve the sharing of protons between atoms.
- E) Covalent bonds involve the transfer of electrons between atoms; ionic bonds involve the sharing of electrons between atoms.

Answer: C

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3

33) In ammonium chloride salt ( $\text{NH}_4\text{Cl}$ ) the anion is a single chloride ion,  $\text{Cl}^-$ . What is the cation of  $\text{NH}_4\text{Cl}$ ?

- A) N, with a charge of +1
- B)  $\text{NH}$ , with a charge of +1
- C)  $\text{H}_3$ , with a charge of +1
- D)  $\text{NH}_4$ , with a charge of +1
- E)  $\text{NH}_4$ , with a charge of +4

Answer: D

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3

34) The atomic number of chlorine is 17. The atomic number of magnesium is 12. What is the formula for magnesium chloride?

- A)  $\text{MgCl}$
- B)  $\text{MgCl}_2$
- C)  $\text{Mg}_2\text{Cl}$
- D)  $\text{Mg}_2\text{Cl}_2$
- E)  $\text{MgCl}_3$

Answer: B

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3

35) How many electron pairs are shared between carbon atoms in a molecule that has the formula  $C_2H_4$ ?

- A) 0
- B) 1
- C) 2
- D) 3
- E) 4

Answer: C

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3

36) Which bond or interaction would be difficult to disrupt when compounds are put into water?

- A) covalent bond
- B) hydrogen bond
- C) van der Waals interaction
- D) ionic bond
- E) either covalent bond or ionic bond

Answer: A

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3

37) Van der Waals interactions result when

- A) hybrid orbitals overlap.
- B) electrons are not symmetrically distributed in a molecule.
- C) molecules held by ionic bonds react with water.
- D) two polar covalent bonds react.
- E) a hydrogen atom loses an electron.

Answer: B

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3

38) What bonding or interaction is most likely to occur among a broad array of molecules of various types (polar, nonpolar, hydrophilic, hydrophobic)?

- A) covalent bonding
- B) polar covalent bonding
- C) ionic bonding
- D) hydrogen bonding
- E) van der Waals interactions

Answer: E

Topic: Concept 2.3

Skill: Synthesis/Evaluation

Learning Outcome: 2.3

39) Which of the following is (are) *not* considered to be a weak molecular interaction?

- A) a covalent bond
- B) a van der Waals interaction
- C) an ionic bond in the presence of water
- D) a hydrogen bond
- E) both a hydrogen bond and a covalent bond

Answer: A

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3

40) Which of the following would be regarded as compounds?

- A) H<sub>2</sub>O, O<sub>2</sub>, and CH<sub>4</sub>
- B) H<sub>2</sub>O and O<sub>2</sub>
- C) O<sub>2</sub> and CH<sub>4</sub>
- D) CH<sub>4</sub> and O<sub>2</sub>, but not H<sub>2</sub>O
- E) H<sub>2</sub>O and CH<sub>4</sub>, but not O<sub>2</sub>

Answer: E

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3

41) What is the maximum number of hydrogen atoms that can be covalently bonded in a molecule containing two carbon atoms?

- A) 2
- B) 3
- C) 4
- D) 6
- E) 8

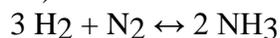
Answer: D

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3

42) Which of the following is true for this reaction?



- A) The reaction is nonreversible.
- B) Hydrogen and nitrogen are the reactants of the reverse reaction.
- C) Hydrogen and nitrogen are the products of the forward reaction.
- D) Ammonia is being formed and decomposed.
- E) Hydrogen and nitrogen are being decomposed.

Answer: D

Topic: Concept 2.4

Skill: Knowledge/Comprehension

Learning Outcome: 2.4

43) Which of the following correctly describes chemical equilibrium?

- A) Forward and reverse reactions continue with no effect on the concentrations of the reactants and products.
- B) The concentrations of the products are higher than the concentrations of the reactants.
- C) Forward and reverse reactions have stopped so that the concentration of the reactants equals the concentration of the products.
- D) Reactions stop only when all reactants have been converted to products.
- E) There are equal concentrations of reactants and products, and the reactions have stopped.

Answer: A

Topic: Concept 2.4

Skill: Knowledge/Comprehension

Learning Outcome: 2.4

44) Which of the following correctly describes any reaction that has reached chemical equilibrium?

- A) The concentration of the reactants equals the concentration of the products.
- B) The rate of the forward reaction is equal to the rate of the reverse reaction.
- C) All of the reactants have been converted to the products of the reaction.
- D) All of the products have been converted to the reactants of the reaction.
- E) Both the forward and the reverse reactions have stopped with no net effect on the concentration of the reactants and the products.

Answer: B

Topic: Concept 2.4

Skill: Knowledge/Comprehension

Learning Outcome: 2.4

45) Which of the following explains most specifically the attraction of water molecules to one another?

- A) nonpolar covalent bond
- B) polar covalent bond
- C) ionic bond
- D) hydrogen bond
- E) hydrophobic interaction

Answer: D

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.3, 2.5

46) If a salamander relied on hydrogen bonds to cling to surfaces, what type of surface would cause the most problems for this animal?

- A) a surface coated with a thin film of water
- B) a surface made with carbon and hydrogen atoms covalently bonded together
- C) a surface made with carbon, hydrogen, and oxygen atoms covalently bonded together
- D) a surface made with carbon, hydrogen, nitrogen, and oxygen atoms covalently bonded together
- E) a surface made with silicon and oxygen atoms covalently bonded together

Answer: B

Topic: Concept 2.5

Skill: Synthesis/Evaluation

Learning Outcome: 2.3, 2.5

47) 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.
- E) van der Waals interactions.

Answer: C

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.3, 2.5

48) The slight negative charge at one end of one water molecule is attracted to the slight 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 hydrophilic bond
- E) a van der Waals interaction

Answer: B

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.3, 2.5

- 49) The partial negative charge in a molecule of water occurs because
- A) the oxygen atom acquires an additional electron.
  - B) the electrons shared between the oxygen and hydrogen atoms spend more time around the oxygen atom's nucleus than around the hydrogen atom's nucleus.
  - C) the oxygen atom has two pairs of electrons in its valence shell that are not neutralized by hydrogen atoms.
  - D) the oxygen atom forms hybrid orbitals that distribute electrons unequally around the oxygen nucleus.
  - E) one of the hydrogen atoms donates an electron to the oxygen atom.

Answer: B

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.3, 2.5

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

Answer: E

Topic: Concept 2.5

Skill: Synthesis/Evaluation

Learning Outcome: 2.3, 2.5

- 51) Water molecules are able to form hydrogen bonds with
- A) compounds that have polar covalent bonds.
  - B) oils.
  - C) oxygen gas (O<sub>2</sub>) molecules.
  - D) chloride ions.
  - E) any compound that is not soluble in water.

Answer: A

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.3, 2.5

- 52) Which of the following effects is produced by the high surface tension of water?
- A) Lakes don't freeze solid in winter, despite low temperatures.
  - B) A water strider can walk across the surface of a small pond.
  - C) Organisms resist temperature changes, although they give off heat due to chemical reactions.
  - D) Evaporation of sweat from the skin helps to keep people from overheating.
  - E) Water flows upward from the roots to the leaves in plants.

Answer: B

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

53) Which of the following takes place as an ice cube cools a drink?

- A) Molecular collisions in the drink increase.
- B) Kinetic energy in the drink decreases.
- C) A calorie of heat energy is transferred from the ice to the water of the drink.
- D) The specific heat of the water in the drink decreases.
- E) Evaporation of the water in the drink increases.

Answer: B

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

54) A dietary Calorie equals 1 kilocalorie. Which of the following statements correctly defines 1 kilocalorie?

- A) 1,000 calories, or the amount of heat required to raise the temperature of 1 g of water by 1,000°C
- B) 100 calories, or the amount of heat required to raise the temperature of 100 g of water by 1°C
- C) 10,000 calories, or the amount of heat required to raise the temperature of 1 kg of water by 1°F
- D) 1,000 calories, or the amount of heat required to raise the temperature of 1 kg of water by 1°C
- E) 1,000 calories, or the amount of heat required to raise the temperature of 100 g of water by 100°C

Answer: D

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

55) The nutritional information on a cereal box shows that one serving of a dry cereal has 200 kilocalories. If one were to burn one serving of the cereal, the amount of heat given off would be sufficient to raise the temperature of 20 kg of water how many degrees Celsius?

- A) 0.2°C
- B) 1.0°C
- C) 2.0°C
- D) 10.0°C
- E) 20.0°C

Answer: D

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

- 56) Liquid water's high specific heat is mainly a consequence of the
- A) small size of the water molecules.
  - B) high specific heat of oxygen and hydrogen atoms.
  - C) absorption and release of heat when hydrogen bonds break and form.
  - D) fact that water is a poor heat conductor.
  - E) higher density of liquid water than solid water (ice).

Answer: C

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

- 57) Which type of bond must be broken for water to vaporize?
- A) ionic bonds
  - B) both hydrogen bonds and ionic bonds
  - C) polar covalent bonds
  - D) hydrogen bonds
  - E) both polar covalent bonds and hydrogen bonds

Answer: D

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

- 58) Temperature usually increases when water condenses. Which behavior of water is most directly responsible for this phenomenon?
- A) the change in density when it condenses to form a liquid or solid
  - B) reactions with other atmospheric compounds
  - C) the release of heat by the formation of hydrogen bonds
  - D) the release of heat by the breaking of hydrogen bonds
  - E) the high surface tension of water

Answer: C

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

- 59) 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) Ice always has air bubbles that keep it afloat.
  - D) Hydrogen bonds stabilize and keep the molecules of ice farther apart than the water molecules of liquid water.
  - E) The crystalline lattice of ice causes it to be denser than liquid water.

Answer: D

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

- 60) 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.
  - E) charged molecules that hydrogen-bond with water molecules.

Answer: A

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

- 61) One mole (mol) of glucose (molecular mass = 180 daltons) is
- A)  $180 \times 10^{23}$  molecules of glucose.
  - B) 1 kg of glucose dissolved in 1 L of solution.
  - C) the largest amount of glucose that can be dissolved in 1 L of solution.
  - D) 180 kilograms of glucose.
  - E) both 180 grams of glucose and  $6.02 \times 10^{23}$  molecules of glucose.

Answer: E

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

- 62) How many molecules of glucose ( $C_6H_{12}O_6$  molecular mass = 180 daltons) would be present in 90 grams of glucose?

- A)  $90 \times 10^{23}$
- B)  $(6.02/180) \times 10^{23}$
- C)  $(6.02/90) \times 10^{23}$
- D)  $(90 \times 6.02) \times 10^{23}$
- E)  $(90/180) \times 6.02 \times 10^{23}$

Answer: E

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

- 63) How many molecules of glycerol ( $C_3H_8O_3$ ; molecular mass = 92) would be present in 1 L of a 1 M glycerol solution?

- A)  $1 \times 10^6$
- B)  $14 \times 6.02 \times 10^{23}$
- C)  $92 \times 6.02 \times 10^{23}$
- D)  $6.02 \times 10^{26}$
- E)  $6.02 \times 10^{23}$

Answer: E

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

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

Answer: C

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

65) The molar mass of glucose is 180 g/mol. Which of the following procedures should you carry out to make a 1 M solution of glucose?

- A) Dissolve 1 g of glucose in 1 L of water.
- B) Dissolve 180 g of glucose in 1 L of water.
- C) Dissolve 180 g of glucose in 180 g of water.
- D) Dissolve 180 milligrams (mg) of glucose in 1 L of water.
- E) Dissolve 180 g of glucose in 0.8 L of water, and then add more water until the total volume of the solution is 1 L.

Answer: E

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

66) The molar mass of glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>) is 180 g/mol. Which of the following procedures should you carry out to make a 0.5 M solution of glucose?

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

Answer: B

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

67) You have a freshly prepared 0.1 M solution of glucose in water. Each liter of this solution contains how many glucose molecules?

- A)  $6.02 \times 10^{23}$
- B)  $3.01 \times 10^{23}$
- C)  $6.02 \times 10^{24}$
- D)  $12.04 \times 10^{23}$
- E)  $6.02 \times 10^{22}$

Answer: E

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

68) The molecular weight of water is 18 daltons. What is the molarity of 1 liter of pure water? (*Hint: Note that 1 liter of pure water has a mass of 1 kg.*)

- A) 55.6 M
- B) 18 M
- C) 37 M
- D) 0.66 M
- E) 1.0 M

Answer: A

Topic: Concept 2.5

Skill: Synthesis/Evaluation

Learning Outcome: 2.5

69) You have a freshly prepared 1 M solution of glucose in water. You carefully pour out a 100-mL sample of that solution. How many glucose molecules are included in that 100-mL sample?

- A)  $6.02 \times 10^{23}$
- B)  $3.01 \times 10^{23}$
- C)  $6.02 \times 10^{24}$
- D)  $12.04 \times 10^{23}$
- E)  $6.02 \times 10^{22}$

Answer: E

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

70) A strong acid like HCl

- A) ionizes completely in an aqueous solution.
- B) increases the pH when added to an aqueous solution.
- C) reacts with strong bases to create a buffered solution.
- D) is a strong buffer at low pH.
- E) both ionizes completely in aqueous solutions and is a strong buffer at low pH.

Answer: A

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

71) Which of the following ionizes completely in solution and is considered to be a strong base (alkali)?

- A) NaCl
- B) HCl
- C) NH<sub>3</sub>
- D) H<sub>2</sub>CO<sub>3</sub>
- E) NaOH

Answer: E

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

72) 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 ionizes completely in water.
- B) It is a strong base that ionizes completely in water.
- C) It is a weak acid.
- D) It is a weak base.
- E) It is neither an acid nor a base.

Answer: A

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

73) A given solution contains 0.0001(10<sup>-4</sup>) moles of hydrogen ions (H<sup>+</sup>) per liter. Which of the following best describes this solution?

- A) acidic: will accept H<sup>+</sup> from both strong and weak acids
- B) basic: will accept H<sup>+</sup> from both strong and weak acids
- C) acidic: will give H<sup>+</sup> to weak acids, but accept H<sup>+</sup> from strong acids
- D) basic: will give H<sup>+</sup> to weak acids, but accept H<sup>+</sup> from weak acids
- E) acidic: will give H<sup>+</sup> to both strong and weak acids

Answer: C

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

74) A solution contains  $0.0000001(10^{-7})$  moles of hydroxyl ions ( $\text{OH}^-$ ) per liter. Which of the following best describes this solution?

- A) acidic:  $\text{H}^+$  acceptor
- B) basic:  $\text{H}^+$  acceptor
- C) acidic:  $\text{H}^+$  donor
- D) basic:  $\text{H}^+$  donor
- E) neutral

Answer: E

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

75) What is the pH of a solution with a hydroxyl ion ( $\text{OH}^-$ ) concentration of  $10^{-12} M$ ?

- A) pH 2
- B) pH 4
- C) pH 10
- D) pH 12
- E) pH 14

Answer: A

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

76) What is the pH of a 1-millimolar NaOH solution?

- A) pH 3
- B) pH 8
- C) pH 9
- D) pH 10
- E) pH 11

Answer: E

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

77) Which of the following solutions would require the greatest amount of base to be added to bring the solution to neutral pH?

- A) gastric juice at pH 2
- B) vinegar at pH 3
- C) tomato juice at pH 4
- D) black coffee at pH 5
- E) household bleach at pH 12

Answer: A

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

78) What is the hydrogen ion ( $H^+$ ) concentration of a solution of pH 8?

- A) 8 M
- B)  $8 \times 10^{-6}$  M
- C) 0.01 M
- D)  $10^{-8}$  M
- E)  $10^{-6}$  M

Answer: D

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

79) If the pH of a solution is decreased from 9 to 8, it means that the

- A) concentration of  $H^+$  has decreased to one-tenth (1/10) what it was at pH 9.
- B) concentration of  $H^+$  has increased tenfold (10X) compared to what it was at pH 9.
- C) concentration of  $OH^-$  has increased tenfold (10X) compared to what it was at pH 9.
- D) concentration of  $OH^-$  has decreased to one-tenth (1/10) what it was at pH 9.
- E) concentration of  $H^+$  has increased tenfold (10X) and the concentration of  $OH^-$  has decreased to one-tenth (1/10) what they were at pH 9.

Answer: E

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

80) If the pH of a solution is increased from pH 5 to pH 7, it means that the

- A) concentration of  $H^+$  is twice (2X) what it was at pH 5.
- B) concentration of  $H^+$  is one-half (1/2) what it was at pH 5.
- C) concentration of  $OH^-$  is 100 times greater than what it was at pH 5.
- D) concentration of  $OH^-$  is one-hundredth (0.01X) what it was at pH 5.
- E) concentration of  $H^+$  is 100 times greater and the concentration of  $OH^-$  is one-hundredth what they were at pH 5.

Answer: C

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

81) One liter of a solution of pH 2 has how many more hydrogen ions ( $H^+$ ) than 1 L of a solution of pH 6?

- A) 4 times more
- B) 16 times more
- C) 40,000 times more
- D) 10,000 times more
- E) 100,000 times more

Answer: D

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

82) One liter of a solution of pH 9 has how many more hydroxyl ions ( $OH^-$ ) than 1 L of a solution of pH 4?

- A) 5 times more
- B) 32 times more
- C) 50,000 times more
- D) 10,000 times more
- E) 100,000 times more

Answer: E

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

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

- A) They maintain a constant pH when bases are added to them but not when acids are added to them.
- B) They maintain a constant pH when acids are added to them but not when bases are added to them.
- C) They maintain a relatively constant pH of approximately 7 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.
- E) They are found only in living systems and biological fluids.

Answer: D

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

- 84) Buffers are substances that help resist shifts in pH by
- A) releasing  $H^+$  to a solution when acids are added.
  - B) donating  $H^+$  to a solution when bases are added.
  - C) releasing  $OH^-$  to a solution when bases are added.
  - D) accepting  $H^+$  from a solution when acids are added.
  - E) both donating  $H^+$  to a solution when bases are added and accepting  $H^+$  when acids are added.

Answer: E

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

85) One of the buffers that contributes 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,



If the pH of the blood drops, one would expect

- A) a decrease in the concentration of  $H_2CO_3$  and an increase in the concentration of  $HCO_3^-$ .
- B) the concentration of hydroxide ion ( $OH^-$ ) to increase.
- C) the concentration of bicarbonate ion ( $HCO_3^-$ ) to increase.
- D) the  $HCO_3^-$  to act as a base and remove excess  $H^+$  with the formation of  $H_2CO_3$ .
- E) the  $HCO_3^-$  to act as an acid and remove excess  $H^+$  with the formation of  $H_2CO_3$ .

Answer: D

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

86) One of the buffers that contributes to pH stability in human blood is carbonic acid ( $\text{H}_2\text{CO}_3$ ). 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 ( $\text{H}^+$ ). Thus,



If the pH of the blood increases, 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) an increase in the concentration of  $\text{H}_2\text{CO}_3$  and a decrease in the concentration of  $\text{HCO}_3^-$ .
- C) a decrease in the concentration of  $\text{HCO}_3^-$  and an increase in the concentration of  $\text{H}^+$ .
- D) an increase in the concentration of  $\text{HCO}_3^-$  and a decrease in the concentration of  $\text{OH}^-$ .
- E) a decrease in the concentration of  $\text{HCO}_3^-$  and an increase in the concentration of both  $\text{H}_2\text{CO}_3$  and  $\text{H}^+$ .

Answer: A

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

87) Assume that acid rain has lowered the pH of a particular lake to pH 4.0. What is the hydroxyl ion concentration of this lake?

- A)  $1 \times 10^{-10}$  mol of hydroxyl ion per liter of lake water
- B)  $1 \times 10^{-4}$  mol of hydroxyl ion per liter of lake water
- C) 10.0 M with regard to hydroxyl ion concentration
- D) 4.0 M with regard to hydroxyl ion concentration
- E)  $1 \times 10^{-4}$  mol of hydroxyl ion per liter of lake water and 4.0 M with regard to hydrogen ion concentration

Answer: A

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

88) Research indicates that acid precipitation can damage certain marine organisms by

- A) buffering ocean waters.
- B) decreasing the  $\text{H}^+$  concentration in oceans.
- C) increasing the  $\text{OH}^-$  concentration in oceans.
- D) decreasing the concentration of carbonate ions in oceans.
- E) both decreasing the  $\text{H}^+$  concentration and increasing the  $\text{OH}^-$  concentration in oceans.

Answer: D

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

89) 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 ( $H^+$ ).
- B) the concentration of hydrogen ions in solution X is 30 times as great as the concentration of hydrogen ions in solution Y.
- C) the concentration of hydrogen ions in solution Y is 1,000 times as great as the concentration of hydrogen ions in solution X.
- D) the concentration of hydrogen ions in solution X is 3 times as great as the concentration of hydrogen ions in solution Y.
- E) the concentration of hydrogen ions in solution X is 1,000 times as great as the concentration of hydrogen ions in solution Y.

Answer: E

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

90) If a solution has a pH of 7, this means that

- A) there are no  $H^+$  ions in the water.
- B) this is a solution of pure water.
- C) the concentration of  $H^+$  ions in the water equals the concentration of  $OH^-$  ions in the water.
- D) this is a solution of pure water, and the concentration of  $H^+$  ions in the water is  $10^{-7} M$ .
- E) this is a solution of pure water, and the concentration of  $H^+$  ions equals the concentration of  $OH^-$  ions in the water.

Answer: C

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

91) Carbon dioxide ( $CO_2$ ) is readily soluble in water, according to the equation  $CO_2 + H_2O \leftrightarrow H_2CO_3$ . Carbonic acid ( $H_2CO_3$ ) is a weak acid. Respiring cells release  $CO_2$  into the bloodstream. What will be the effect on the pH of blood as that blood first comes in contact with respiring cells?

- A) Blood pH will decrease slightly.
- B) Blood pH will increase slightly.
- C) Blood pH will remain unchanged.
- D) Blood pH will first increase, then decrease as  $CO_2$  combines with hemoglobin.
- E) Blood pH will first decrease, then increase sharply as  $CO_2$  combines with hemoglobin.

Answer: A

Topic: Concept 2.5

Skill: Synthesis/Evaluation

Learning Outcome: 2.5

92) A beaker contains 100 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 results of this mixing?

- A) The concentration of Na<sup>+</sup> ion will rise.
- B) The concentration of Cl<sup>-</sup> ion will be 0.1 M.
- C) The concentration of undissociated H<sub>2</sub>O molecules will remain unchanged.
- D) The pH of the beaker's contents will be neutral.
- E) The pH of the beaker's contents will decrease.

Answer: E

Topic: Concept 2.5

Skill: Synthesis/Evaluation

Learning Outcome: 2.5

93) Equal volumes (5 mL) of vinegar from a freshly opened bottle are added to each of the following solutions. After complete mixing, which of the mixtures will have the highest pH?

- A) 100 mL of pure water
- B) 100 mL of freshly brewed coffee
- C) 100 mL of household cleanser containing 0.5 M ammonia
- D) 100 mL of freshly squeezed lemon juice
- E) 100 mL of tomato juice

Answer: C

Topic: Concept 2.5

Skill: Synthesis/Evaluation

Learning Outcome: 2.5

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

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

Answer: D

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

95) How would acidification of seawater affect marine organisms?

- A) Acidification would increase dissolved carbonate concentrations and promote faster growth of corals and shell-building animals.
- B) Acidification would decrease dissolved carbonate concentrations and promote faster growth of corals and shell-building animals.
- C) Acidification would increase dissolved carbonate concentrations and hinder growth of corals and shell-building animals.
- D) Acidification would decrease dissolved carbonate concentrations and hinder growth of corals and shell-building animals.
- E) Acidification would increase dissolved bicarbonate concentrations, and cause increased calcification of corals and shellfish.

Answer: D

Topic: Concept 2.5

Skill: Knowledge/Comprehension

Learning Outcome: 2.5

96) One idea to mitigate the effects of burning fossil fuels on atmospheric CO<sub>2</sub> concentrations is to pipe liquid CO<sub>2</sub> into the ocean at depths of 2,500 feet or greater. At the high pressures at such depths, CO<sub>2</sub> is heavier than water. What potential effects might result from implementing such a scheme?

- A) increased photosynthetic carbon fixation because of the increased dissolved carbon dioxide in the deep water
- B) increased carbonate concentrations in the deep waters
- C) increased growth of corals from a change in the carbonate—bicarbonate equilibrium
- D) no effect because carbon dioxide is not soluble in water
- E) both increased acidity of the deep waters and changes in the growth of bottom-dwelling organisms with calcium carbonate shells

Answer: E

Topic: Concept 2.5

Skill: Synthesis/Evaluation

Learning Outcome: 2.5

97) If the cytoplasm of a cell is at pH 7, and the mitochondrial matrix is at pH 8, this means that

- A) the concentration of H<sup>+</sup> ions is tenfold higher in the cytoplasm than in the mitochondrial matrix.
- B) the concentration of H<sup>+</sup> ions is tenfold higher in the mitochondrial matrix than in the cytoplasm.
- C) the concentration of H<sup>+</sup> ions in the cytoplasm is 7/8 the concentration in the mitochondrial matrix.
- D) the mitochondrial matrix is more acidic than the cytoplasm.
- E) the concentration of H<sup>+</sup> ions in the cytoplasm is 8/7 the concentration in the mitochondrial matrix.

Answer: A

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

## 2.2 Art Questions

Atom 1	Atom 2
${}^1_1\text{H}$	${}^3_1\text{H}$

**Figure 2.1**

1) Which of the following best describes the relationship between the atoms described in Figure 2.1?

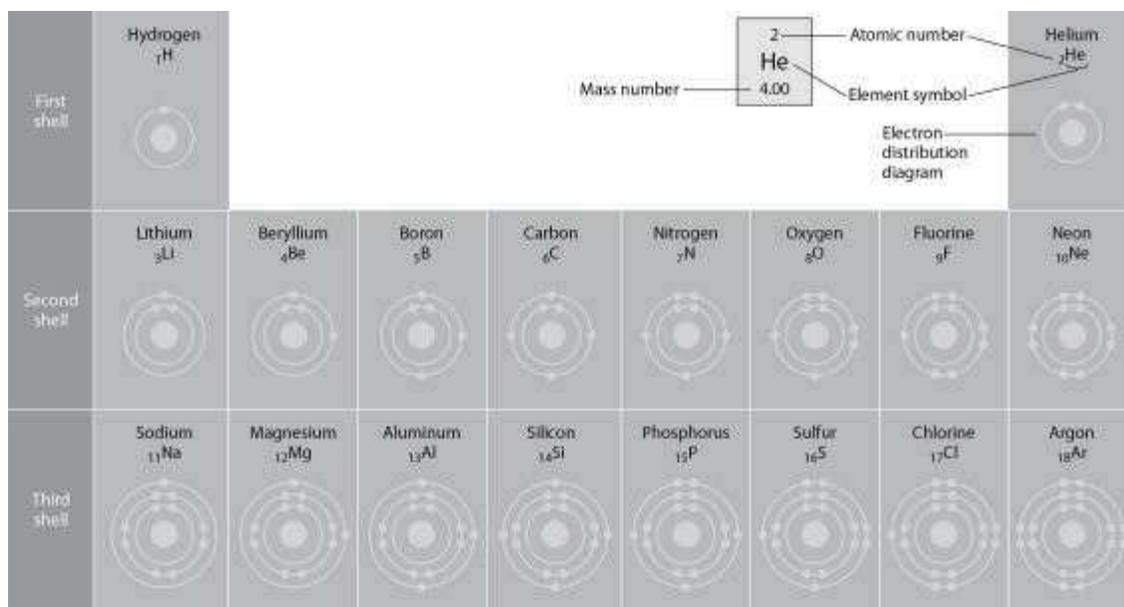
- A) They are isomers.
- B) They are polymers.
- C) They are isotopes.
- D) They contain 1 and 3 protons, respectively.
- E) They each contain 1 neutron.

Answer: C

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2



**Figure 2.2**

2) Refer to Figure 2.2 (first three rows of the periodic table). If life arose on a planet where carbon is absent, which element might fill the role of carbon?

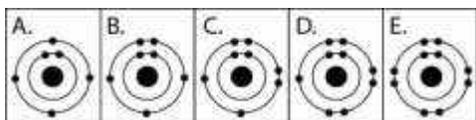
- A) boron
- B) silicon
- C) nitrogen
- D) aluminum
- E) phosphorus

Answer: B

Topic: Concept 2.2

Skill: Synthesis/Evaluation

Learning Outcome: 2.2



**Figure 2.3**

3) Which drawing in Figure 2.3 depicts the electron configuration of an element with chemical properties most similar to those of helium ( ${}^2\text{He}$ )?

- A) A
- B) B
- C) C
- D) D
- E) E

Answer: E

Topic: Concept 2.2

Skill: Application/Analysis

Learning Outcome: 2.2

4) Which drawing in Figure 2.3 depicts the electron configuration of an atom that can form covalent bonds with two hydrogen atoms?

- A) A
- B) B
- C) C
- D) D
- E) E

Answer: C

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3

5) Which drawing in Figure 2.3 depicts the electron configuration of an atom capable of forming three covalent bonds with other atoms?

- A) A
- B) B
- C) C
- D) D
- E) E

Answer: B

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3

6) Which drawing in Figure 2.3 is of the electron configuration of a sodium  ${}_{11}\text{Na}^+$  ion?

- A) A
- B) B
- C) C
- D) D
- E) E

Answer: E

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3

7) Which drawing in Figure 2.3 depicts an atom with a valence of 3?

- A) A
- B) B
- C) C
- D) D
- E) E

Answer: B

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

8) Which drawing in Figure 2.3 depicts an atom with a valence of 2?

- A) A
- B) B
- C) C
- D) D
- E) E

Answer: C

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

Atomic mass →	12	16	1	14	32	31
	C	O	H	N	S	P
Atomic number →	6	8	1	7	16	15

**Figure 2.4**

9) In Figure 2.4, how many electrons does nitrogen have in its valence shell?

- A) 2
- B) 5
- C) 7
- D) 8
- E) 14

Answer: B

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

10) In Figure 2.4, how many unpaired electrons does phosphorus have in its valence shell?

- A) 15
- B) 2
- C) 3
- D) 7
- E) 5

Answer: C

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

11) How many neutrons are present in the nucleus of a phosphorus-32 ( $^{32}\text{P}$ ) atom (see Figure 2.4)?

- A) 5
- B) 15
- C) 16
- D) 17
- E) 32

Answer: D

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

12) How many electrons does an atom of sulfur have in its valence shell (see Figure 2.4)?

- A) 4
- B) 6
- C) 8
- D) 16
- E) 32

Answer: B

Topic: Concept 2.2

Skill: Knowledge/Comprehension

Learning Outcome: 2.2

13) Based on electron configuration, which of these elements in Figure 2.4 would exhibit a chemical behavior most like that of oxygen?

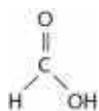
- A) carbon
- B) hydrogen
- C) nitrogen
- D) sulfur
- E) phosphorus

Answer: D

Topic: Concept 2.2

Skill: Application/Analysis

Learning Outcome: 2.2



**Figure 2.5**

14) Figure 2.5 shows a representation of formic acid. A formic acid molecule

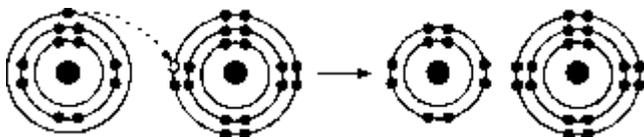
- A) will form hydrogen bonds with water molecules.
- B) has a tetrahedral configuration of hybrid electron orbitals for the carbon atom.
- C) consists of largely nonpolar covalent bonds.
- D) is held together by hydrogen bonds.
- E) has a tetrahedral shape and will form hydrogen bonds with water molecules.

Answer: A

Topic: Concept 2.3

Skill: Synthesis/Evaluation

Learning Outcome: 2.3



**Figure 2.6**

- 15) What results from the chemical reaction illustrated in Figure 2.6?
- A) a cation with a net charge of +1
  - B) a cation with a net charge of -1
  - C) an anion with a net charge of +1
  - D) an anion with a net charge of -1
  - E) a cation with a net charge of +1 and an anion with a net charge of -1

Answer: E

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3

- 16) What is the atomic number of the cation formed in the reaction illustrated in Figure 2.6?

- A) 1
- B) 8
- C) 10
- D) 11
- E) 16

Answer: D

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3



**Figure 2.7**

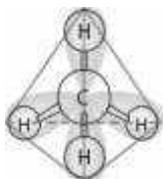
- 17) What causes the shape of the molecule shown in Figure 2.7?
- A) the configuration of the 2 *p* orbitals in the carbon atom
  - B) the configuration of the 1 *s* orbital in the carbon atom
  - C) the configuration of the *sp* hybrid orbitals of the electrons shared between the carbon and hydrogen atoms
  - D) the packing of the carbon and hydrogen atoms in a crystal lattice
  - E) hydrogen bonding configurations between the carbon and hydrogen atoms

Answer: C

Topic: Concept 2.3

Skill: Knowledge/Comprehension

Learning Outcome: 2.3



**Figure 2.8**

18) In the methane molecule shown in Figure 2.8, bonds have formed that include both the  $s$  orbital valence electrons of the hydrogen atoms and the  $p$  orbital valence electrons of the carbon. The electron orbitals in these bonds are said to be

- A) double orbitals.
- B) tetrahedral orbitals.
- C) complex orbitals.
- D) hybrid orbitals.
- E) polar orbitals.

Answer: D

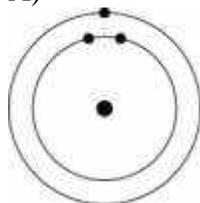
Topic: Concept 2.3

Skill: Knowledge/Comprehension

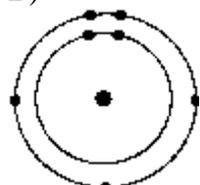
Learning Outcome: 2.3

19) Which one of the atoms shown would be most likely to form a cation with a charge of +1?

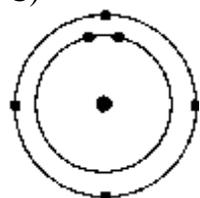
A)



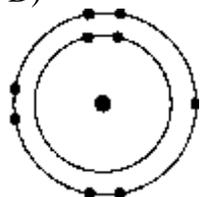
B)



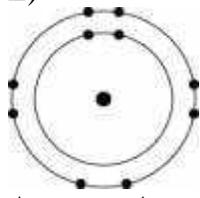
C)



D)



E)



Answer: A

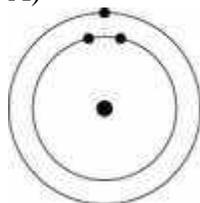
Topic: Concept 2.3

Skill: Application/Analysis

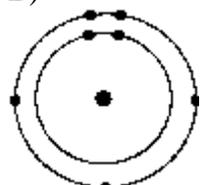
Learning Outcome: 2.3

20) Which one of the atoms shown would be most likely to form an anion with a charge of -1?

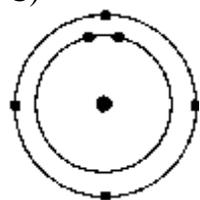
A)



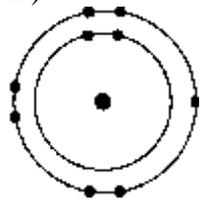
B)



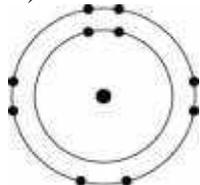
C)



D)



E)



Answer: D

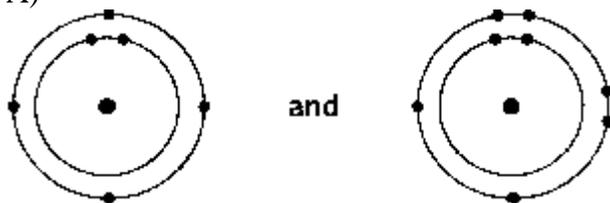
Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3

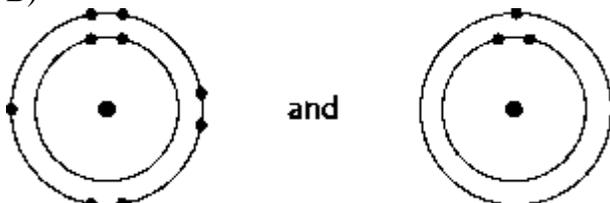
21) Which of the following pairs of atoms would be most likely to form a polar covalent bond?

A)



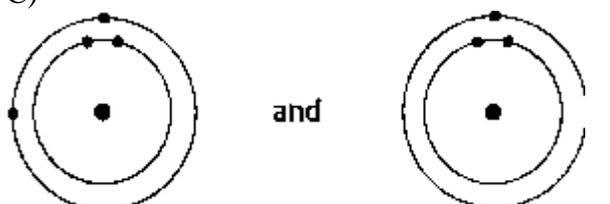
and

B)



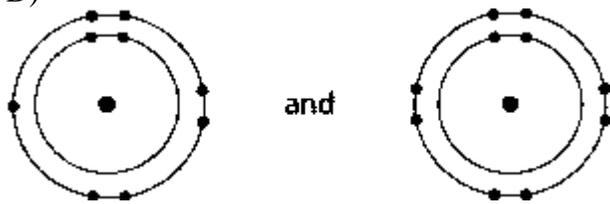
and

C)



and

D)



and

E)



and

Answer: A

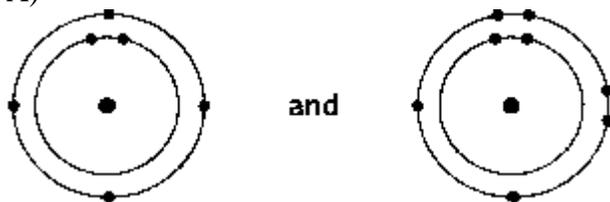
Topic: Concept 2.3

Skill: Application/Analysis

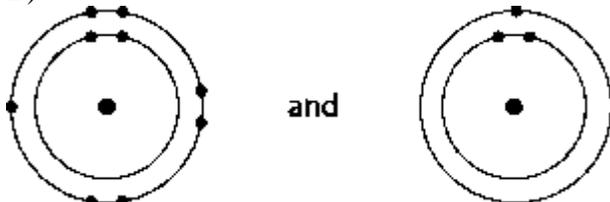
Learning Outcome: 2.3

22) Which one of the following pairs of atoms would be most likely to form ions and thus an ionic bond?

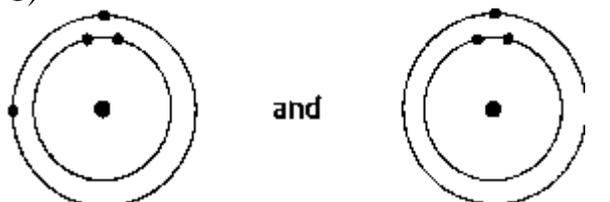
A)



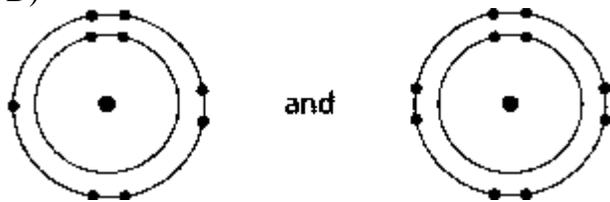
B)



C)



D)



E)

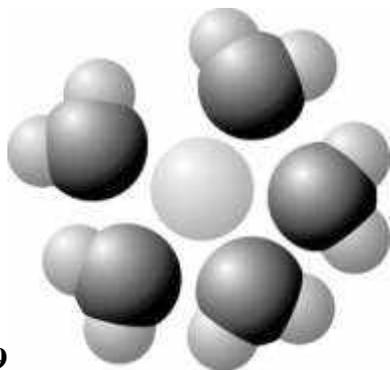


Answer: B

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3



**Figure 2.9**

23) Based on your knowledge of the polarity of water molecules, the solute molecule depicted in Figure 2.9 is most likely

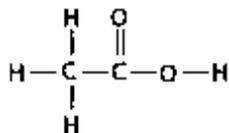
- A) positively charged.
- B) negatively charged.
- C) without charge.
- D) hydrophobic.
- E) nonpolar.

Answer: A

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5



**Figure 2.10**

24) How many grams would be equal to 1 mol of the compound shown in Figure 2.10? (carbon = 12, oxygen = 16, hydrogen = 1)

- A) 29
- B) 30
- C) 60
- D) 150
- E) 342

Answer: C

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

25) How many grams of the compound in Figure 2.10 would be required to make 1 L of a 0.5 *M* solution?

(carbon = 12, oxygen = 16, hydrogen = 1)

- A) 29
- B) 30
- C) 60
- D) 150
- E) 342

Answer: B

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

26) How many grams of the compound in Figure 2.10 would be required to make 2.5 L of a 1 *M* solution?

(carbon = 12, oxygen = 16, hydrogen = 1)

- A) 29
- B) 30
- C) 60
- D) 150
- E) 342

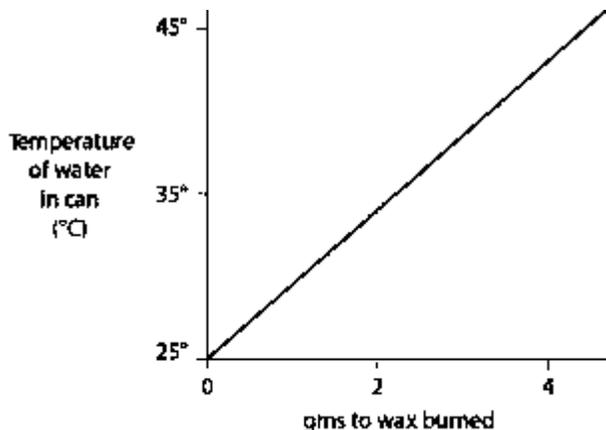
Answer: D

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

27) A small birthday candle is weighed. It is then lighted and placed beneath a metal can containing 100 mL of water. Careful records are kept as the temperature of the water rises. Data from this experiment are shown on the graph. What amount of heat energy is released in the burning of candle wax? (Note that 1 liter of pure water has a mass of 1 kg.)



**Figure 2.11**

- A) 0.5 kilocalories per gram of wax burned
- B) 5 kilocalories per gram of wax burned
- C) 10 kilocalories per gram of wax burned
- D) 20 kilocalories per gram of wax burned
- E) 50 kilocalories per gram of wax burned

Answer: A

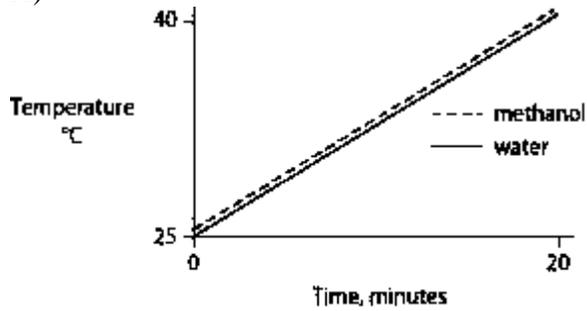
Topic: Concept 2.5

Skill: Synthesis/Evaluation

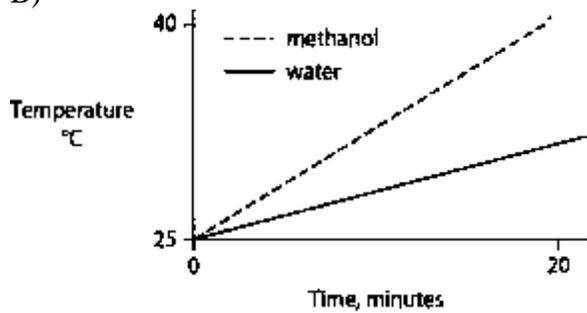
Learning Outcome: 2.5

28) Identical heat lamps are arranged to shine on identical containers of water and 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?

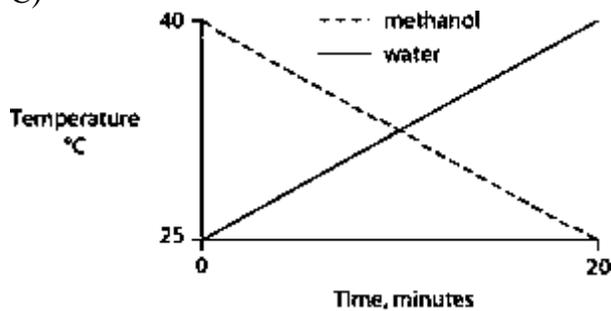
A)



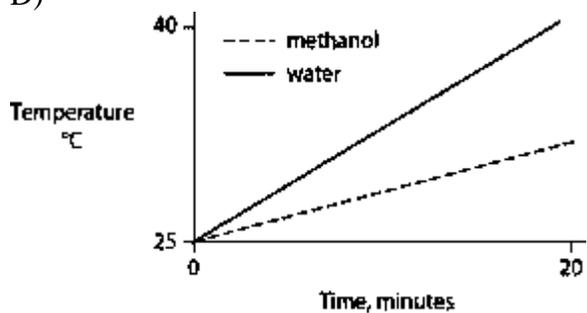
B)



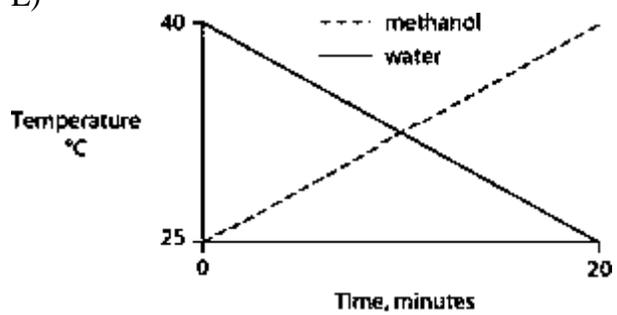
C)



D)



E)



Answer: B

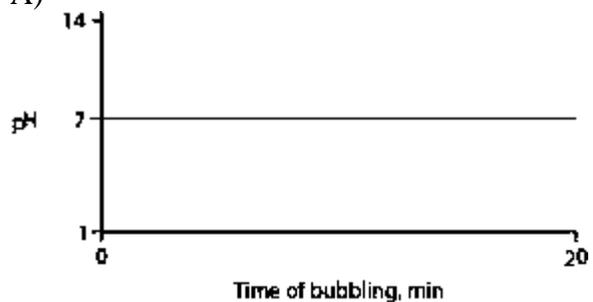
Topic: Concept 2.5

Skill: Synthesis/Evaluation

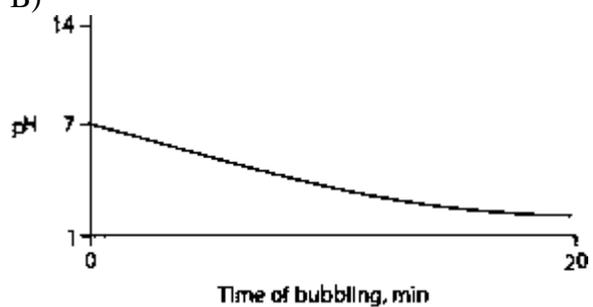
Learning Outcome: 2.5

29) 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?

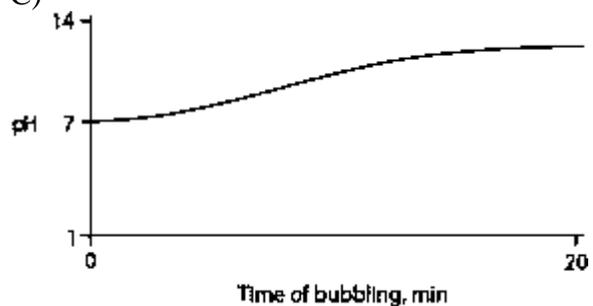
A)



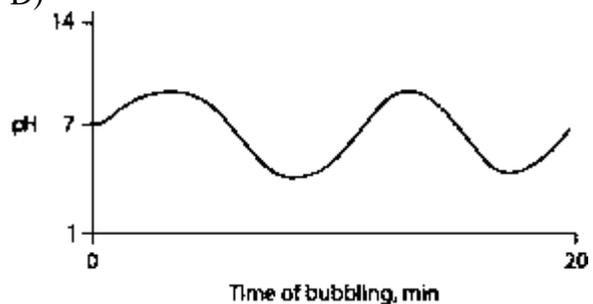
B)

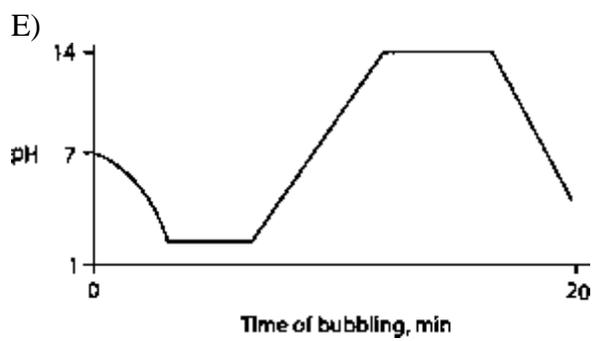


C)



D)





Answer: B

Topic: Concept 2.5

Skill: Synthesis/Evaluation

Learning Outcome: 2.5

## 2.3 Scenario Questions

1) A group of molecular biologists is trying to synthesize a new artificial compound to mimic the effects of a known hormone that influences sexual behavior. The biologists have turned to you for advice. Which of the following compounds is most likely to mimic the effects of the hormone?

- A) a compound with the same number of carbon atoms as the hormone
- B) a compound with the same molecular mass (measured in daltons) as the hormone
- C) a compound with the same three-dimensional shape as part of the hormone
- D) a compound with the same number of orbital electrons as the hormone
- E) a compound with the same number of hydrogen and nitrogen atoms as the hormone

Answer: C

Topic: Concept 2.3

Skill: Application/Analysis

Learning Outcome: 2.3

2) You have two beakers. One contains pure water, the other contains pure methanol (wood alcohol). The covalent bonds of methanol molecules are nonpolar, so there are no hydrogen bonds among methanol molecules. You pour crystals of table salt (NaCl) into each beaker. Predict what will happen.

- A) Equal amounts of NaCl crystals will dissolve in both water and methanol.
- B) NaCl crystals will *not* dissolve in either water or methanol.
- C) NaCl crystals will dissolve readily in water but will not dissolve in methanol.
- D) NaCl crystals will dissolve readily in methanol but will not dissolve in water.
- E) When the first crystals of NaCl are added to water or to methanol, they will not dissolve; but as more crystals are added, the crystals will begin to dissolve faster and faster.

Answer: C

Topic: Concept 2.5

Skill: Application/Analysis

Learning Outcome: 2.5

3) You have two beakers. One contains a solution of HCl at pH = 1.0. The other contains a solution of NaOH at pH = 13. Into a third beaker, you slowly and cautiously pour 20 mL of the HCl and 20 mL of the NaOH. After complete stirring, the pH of the mixture will be

- A) 2.0.
- B) 12.0.
- C) 7.0.
- D) 5.0.
- E) 9.0.

Answer: C

Topic: Concept 2.5

Skill: Synthesis/Evaluation

Learning Outcome: 2.5

## 2.4 End-of-Chapter Questions

1) The reactivity of an atom arises from

- A) the average distance of the outermost electron shell from the nucleus.
- B) the existence of unpaired electrons in the valence shell.
- C) the sum of the potential energies of all the electron shells.
- D) the potential energy of the valence shell.
- E) the energy differences between the electron shells.

Answer: B

Topic: End-of-Chapter Questions

Skill: Knowledge/Comprehension

Learning Outcome: No L.O. Specified

2) Which of the following statements correctly describes any chemical reaction that has reached equilibrium?

- A) The concentrations of products and reactants are equal.
- B) The reaction is now irreversible.
- C) Both forward and reverse reactions have halted.
- D) The rates of the forward and reverse reactions are equal.
- E) No reactants remain.

Answer: D

Topic: End-of-Chapter Questions

Skill: Knowledge/Comprehension

Learning Outcome: No L.O. Specified

3) Many mammals control their body temperature by sweating. Which property of water is most directly responsible for the ability of sweat to lower body temperature?

- A) water's change in density when it condenses
- B) water's ability to dissolve molecules in the air
- C) the release of heat by the formation of hydrogen bonds
- D) the absorption of heat by the breaking of hydrogen bonds
- E) water's high surface tension

Answer: D

Topic: End-of-Chapter Questions

Skill: Knowledge/Comprehension

Learning Outcome: No L.O. Specified

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

- A) mass in daltons.
- B) mass in grams.
- C) volume.
- D) number of atoms.
- E) number of molecules.

Answer: E

Topic: End-of-Chapter Questions

Skill: Knowledge/Comprehension

Learning Outcome: No L.O. Specified

5) 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*
- E) 4%

Answer: C

Topic: End-of-Chapter Questions

Skill: Knowledge/Comprehension

Learning Outcome: No L.O. Specified

6) The atomic number of sulfur is 16. Sulfur combines with hydrogen by covalent bonding to form a compound, hydrogen sulfide. Based on the number of valence electrons in a sulfur atom, predict the molecular formula of the compound.

- A) HS
- B) HS<sub>2</sub>
- C) H<sub>2</sub>S
- D) H<sub>3</sub>S<sub>2</sub>
- E) H<sub>4</sub>S

Answer: C

Topic: End-of-Chapter Questions

Skill: Application/Analysis

Learning Outcome: No L.O. Specified

7) What coefficients must be placed in the following blanks so that all atoms are accounted for in the products?



- A) 1; 2
- B) 3; 1
- C) 1; 3
- D) 1; 1
- E) 2; 2

Answer: E

Topic: End-of-Chapter Questions

Skill: Application/Analysis

Learning Outcome: No L.O. Specified

8) 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 liter of cold water weighs about 1 kg.)

A) 50°C

B) 5°C

C) 1°C

D) 100°C

E) 10°C

Answer: E

Topic: End-of-Chapter Questions

Skill: Application/Analysis

Learning Outcome: No L.O. Specified