Biological Science, 4e **(Freeman)**
Chapter 2 Water and Carbon: The Chemical Basis of Life

1) How many electrons are involved in a single covalent bond?
A) one
B) two
C) three
D) four
Answer: B
Reference: Section 2.1
Bloom's Taxonomy: Level 1 Knowledge

2) How many electrons are involved in a double covalent bond?
A) one
B) two
C) three
D) four
Answer: D
Reference: Section 2.1
Bloom's Taxonomy: Level 1 Knowledge

3) If you change the number of neutrons in an atom, you create _____.
A) a cation
B) an anion
C) an isotope
D) a different element
Answer: C
Reference: Section 2.1
Bloom's Taxonomy: Level 3 Application

4) If an atom has a charge of +1, which of the following must be true?
A) It has two more protons than neutrons.
B) It has the same number of protons as electrons.
C) It has one more electron than it does protons.
D) It has one more proton than it does electrons.
Answer: D
Reference: Section 2.1
Bloom's Taxonomy: Level 2 Comprehension

5) Elements found on the left side of the periodic table contain outer shells that are _____; these elements tend to form _____ in solution.
A) almost empty; cations
B) almost empty; anions
C) almost full; cations
D) almost full; anions
Answer: A
Reference: Section 2.1
Bloom's Taxonomy: Level 2 Comprehension

6) You isolate a molecule and determine it is nonpolar. Based on this property, the molecule is largely composed of the elements _____.
A) carbon and oxygen
B) carbon and hydrogen
C) carbon and nitrogen
D) nitrogen and hydrogen
Answer: B
Reference: Section 2.1
Bloom's Taxonomy: Level 2 Comprehension

7) An atom has six electrons in its valence shell. How many single covalent bonds would you expect it to form in most circumstances?
A) one
B) two
C) three
D) six
Answer: B
Reference: Section 2.1
Bloom's Taxonomy: Level 2 Comprehension

8) An atom has four electrons in its valence shell. What types of covalent bonds is it capable of forming?
A) single, double, or triple
B) single and double only
C) four single bonds only
D) two double bonds only
Answer: A
Reference: Section 2.1
Bloom's Taxonomy: Level 2 Comprehension

9) When are atoms most stable?
A) when they have the fewest possible valence electrons
B) when they have the maximum number of unpaired electrons
C) when all of the electron orbitals in the valence shell are filled
D) when all electrons are paired
Answer: C
Reference: Section 2.1
Bloom's Taxonomy: Level 1 Knowledge

10) What holds electrons in a covalent bond?
A) It is the fact that two electrons are paired in the same orbital.
B) The electron sharing that occurs makes the atoms involved smaller and more compact.
C) An increase in potential energy, caused by electrical repulsion of the electrons in the bond, holds the electrons.
D) The negative charges on the electrons are attracted by the positive charges on both nuclei.
Answer: D
Reference: Section 2.1
Bloom's Taxonomy: Level 1 Knowledge

11) Can the atomic mass of an element change?
A) No, it is fixed. If it changes at all then you have formed a different element.
B) Yes. Adding or losing electrons will substantially change the atomic mass.
C) Yes. Adding or losing protons will change the atomic mass without forming a different element.
D) Yes. Adding or losing neutrons will change the atomic mass without forming a different element.
Answer: D
Reference: Section 2.1
Bloom's Taxonomy: Level 2 Comprehension

12) Which of the following is the best description of an atom's physical structure?
A) An atom is a solid mass of material.
B) The particles that form an atom are equidistant from each other.
C) Atoms are little bubbles of space with mass concentrated at the center of the bubble.
D) Atoms are little bubbles of space with mass concentrated on the outside surface of the bubble.
Answer: C
Reference: Section 2.1
Bloom's Taxonomy: Level 2 Comprehension

13) When the atoms involved in a covalent bond have the same electronegativity, what type of bond results?
A) an ionic bond
B) a hydrogen bond
C) a nonpolar covalent bond
D) a polar covalent bond
Answer: C
Reference: Section 2.1
Bloom's Taxonomy: Level 1 Knowledge

14) Which of the following molecules is polar?
A) CH_4
B) C_2H_5COOH
C) C_3H_7OH
D) C_3H_7OH and C_2H_5COOH are polar molecules.
Answer: D
Reference: Section 2.1
Bloom's Taxonomy: Level 3 Application

15) Nitrogen (N) normally forms only three covalent bonds because it has a valence of five. However, ammonium has four covalent bonds, each to a different hydrogen (H) atom (H has a valence of one). Make a sketch of this molecule. Count the number of electrons in your sketch. Compare this number to the number of valence electrons in one N and four H's. What do you predict to be the charge on this molecule?
A) +1
B) -1
C) +2
D) -2
Answer: A
Reference: Section 2.1
Bloom's Taxonomy: Level 3 Application

16) The structural formula for a certain molecule includes a group symbolized -O. The dash next to the oxygen atom means that a single bond exists to another atom, such as a carbon. Based on the valence of oxygen and the number of bonds it normally forms, what is the charge on the oxygen atom in this case?
A) +1
B) -1
C) +2
D) -2
Answer: B
Reference: Section 2.1
Bloom's Taxonomy: Level 3 Application

17) You need to write down information about a molecule, but need to indicate only which atoms it contains and how many of each. Which representation would work best?
A) molecular formula
B) structural formula
C) ball-and-stick model
D) space-filling model
Answer: A
Reference: Section 2.1
Bloom's Taxonomy: Level 1 Knowledge

18) You need to write down information about a molecule that gives the most accurate picture of the relative sizes of the atoms involved and their relationship in space. Which representation would work best?
A) molecular formula
B) structural formula
C) ball-and-stick model
D) space-filling model
Answer: D
Reference: Section 2.1
Bloom's Taxonomy: Level 1 Knowledge

19) Silicon's atomic number is 14; in the periodic table it is directly beneath carbon. Silicon is abundant in the Earth's crust, yet, unlike C, N, O, and H, silicon is not a common element in organisms. What about the atomic structure of silicon probably accounts for this?
A) The nucleus of silicon is probably too small to form long chains of Si-Si molecules (analogous to long chains of carbon molecules).
B) The nucleus of silicon is probably too big to form long chains of Si-Si molecules (analogous to long chains of carbon molecules).
C) Silicon only has three valence electrons, so it can make fewer covalent bonds than carbon.
D) Silicon is too electronegative to be an element common in living organisms.
Answer: B
Reference: Section 2.1
Bloom's Taxonomy: Level 4 Analysis

20) Which of the following is true of carbon?
A) It only forms polar molecules.
B) It can form a maximum of three covalent bonds with other elements.
C) It is highly electronegative.
D) It can form polar and nonpolar bonds.
Answer: D
Reference: Section 2.4
Bloom's Taxonomy: Level 1 Knowledge

21) Water has a high specific heat because of the _____.
A) polar covalent bond formed between the oxygen and a hydrogen of a single water molecule
B) ionic bonds formed between the hydrogen of one water molecule and the oxygen of another water molecule
C) hydrogen bond formed between the hydrogen of one water molecule and the oxygen of another water molecule
D) covalent bond formed between the hydrogen of one water molecule and the oxygen of another water molecule
Answer: C
Reference: Section 2.2
Bloom's Taxonomy: Level 2 Comprehension

22) Which of the following is a property of liquid water?
A) Its density is less than ice.
B) Its specific heat is lower than that for most other substances.
C) Its heat of vaporization is higher than that for most other substances.
D) It is nonpolar.
Answer: C
Reference: Section 2.2
Bloom's Taxonomy: Level 1 Knowledge

23) Which of the following true statements can be attributed to water's high specific heat?
A) Oil and water do not mix well.
B) Our body temperature can take a long time to passively change because it is composed mostly of water.
C) Ice floats on water.
D) Sugar dissolves in hot tea faster than in iced tea.
Answer: B
Reference: Section 2.2
Bloom's Taxonomy: Level 3 Application

24) The sole of a gecko's foot is covered with millions and millions of small, dry “hairs” that make direct contact with surfaces, and allow geckos to walk up walls and dangle from the ceiling. Experiments showed that the “hairs” stick well to strongly hydrophobic, strongly hydrophilic, and electrically neutral surfaces and that covalent bonds were not involved. What noncovalent bond is probably involved in the foot adhering to a surface?
A) ionic bonds
B) hydrogen bonds
C) both hydrogen and ionic bonds
D) neither hydrogen nor ionic bonds
Answer: B
Reference: Section 2.1
Bloom's Taxonomy: Level 3 Application

25) The cities of Portland, Oregon, and Minneapolis, Minnesota, are at about the same latitude, but Minneapolis has much hotter summers and much colder winters than Portland does. Why? (Portland is near the Pacific Ocean; Minneapolis is near a number of large lakes.)
A) They are not at exactly the same latitude.
B) The ocean is so large that it has a highly moderating influence on temperature.
C) Freshwater is more likely to freeze than salt water.
D) Minneapolis is much windier, due to its location in the middle of a continent.
Answer: B
Reference: Section 2.2
Bloom's Taxonomy: Level 3 Application

26) To act as an effective coolant in a car's radiator, a substance has to be a liquid at the temperatures found in your car's engine and 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 vaporization
D) specific heat
Answer: D
Reference: Section 2.2
Bloom's Taxonomy: Level 3 Application

27) Do all human body fluids have the same pH? If not, rank, in the order of low to high, the pH of blood, urine, and stomach acid.
A) Yes. Blood, urine, and stomach acid all have the same pH.
B) No. The pH ranking from low to high is stomach acid, blood, urine.
C) No. The pH ranking from low to high is urine, blood, stomach acid.
D) No. The pH ranking from low to high is stomach acid, urine, blood.
Answer: D
Reference: Section 2.2
Bloom's Taxonomy: Level 1 Knowledge

28) While 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
Reference: Section 2.2
Bloom's Taxonomy: Level 1 Knowledge

29) A pH of 7 is neutral due to the dissociation of water molecules in pure water. How many molecules of water have broken down into a hydroxide ion and a hydronium ion at pH 7?
A) 1 in 1 million
B) 1 in 10 million
C) 1 in 100 million
D) 1 in 1 billion
Answer: B
Reference: Section 2.2
Bloom's Taxonomy: Level 2 Comprehension

30) A solution with a pH of 5 has how many more protons in it than a solution with a pH of 7?
A) 5 times
B) 10 times
C) 100 times
D) 1000 times
Answer: C
Reference: Section 2.2
Bloom's Taxonomy: Level 3 Application

31) Consider the following reaction at equilibrium: $CO_2 + H_2O \leftrightarrow H_2CO_3$. What would be the effect of adding additional H_2CO_3?
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) The amounts of CO_2 and H_2O would decrease.
Answer: B
Reference: Section 2.3
Bloom's Taxonomy: Level 3 Application

32) Which of the following is a violation of the first law of thermodynamics?
A) The amount of energy stored in a plant's cell as sugars after undergoing photosynthesis is less than the amount of sunlight it absorbed.
B) A hydrogen bomb can destroy a large city with only a few pounds of explosive material.
C) All of the energy in the universe today was present when the Big Bang occurred.
D) The universe will eventually die, and it will have no energy left in it.
Answer: D
Reference: Section 2.3
Bloom's Taxonomy: Level 3 Application

33) Which reaction is most spontaneous?
A) a reaction that is slightly exothermic and leads to a slight increase in entropy
B) a reaction that is slightly endothermic and leads to a huge decrease in entropy
C) a reaction that is highly exothermic and leads to a huge decrease in entropy
D) a reaction that is slightly exothermic and leads to a huge increase in entropy
Answer: D
Reference: Section 2.3
Bloom's Taxonomy: Level 2 Comprehension

34) Why are some reactions exothermic?
A) The products have lower potential energy than the reactants.
B) They are spontaneous.
C) They are nonspontaneous.
D) The products have higher entropy (are more disordered) than the reactants.
Answer: A
Reference: Section 2.3
Bloom's Taxonomy: Level 2 Comprehension

35) Ice melts spontaneously at room temperature, even though the process is endothermic. How is this possible?
A) ΔH is small, so melting still obeys the second law of thermodynamics.
B) The Gibbs free-energy relationship does not apply to phase changes such as melting.
C) Water has a very high specific heat.
D) There is a large increase in entropy.
Answer: D
Reference: Section 2.3
Bloom's Taxonomy: Level 3 Application

36) What does it mean to say a system has a ΔG equal to zero?
A) The system does not release or absorb heat.
B) The system is perfectly ordered (no entropy).
C) The total amount of potential energy in the system is zero.
D) The system is at equilibrium.
Answer: D
Reference: Section 2.3
Bloom's Taxonomy: Level 2 Comprehension

37) In the Gibbs free-energy relationship, why is the *T* term necessary?
A) The free-energy change caused by a change in entropy is a function of temperature.
B) The free-energy change caused by a change in potential energy is a function of temperature.
C) The free-energy change caused by a change in electrical charge is a function of temperature.
Answer: A
Reference: Section 2.3
Bloom's Taxonomy: Level 2 Comprehension

38) Which statement best summarizes the essence of chemical evolution?
A) Energy in the form of sunlight or heat was transformed into chemical energy.
B) Instead of being radiated back to space, energy in the form of sunlight or heat was retained in the oceans and atmosphere because of water's high specific heat.
C) Entropy increased.
D) An increasing number of exothermic reactions occurred.
Answer: A
Reference: Section 2.3
Bloom's Taxonomy: Level 3 Application

39) If delta *G* is greater than zero, _____.
A) you have decreased the amount of free energy in the system
B) you have decreased the amount of entropy in the system
C) you have decreased the total amount of energy in the system
D) you have increased the total amount of energy in the system
Answer: B
Reference: Section 2.3
Bloom's Taxonomy: Level 2 Comprehension

40) Why do chemical reactions tend to speed up when the concentration of the reactants is increased?
A) The reactants move faster.
B) The reactants collide more often.
C) The reactants have greater energy.
D) All of the above apply.
Answer: B
Reference: Section 2.3
Bloom's Taxonomy: Level 2 Comprehension

41) During chemical evolution, which of the following occurred in the molecules involved?
A) Entropy decreased while potential energy increased.
B) Entropy increased while potential energy increased.
C) Entropy stayed constant while potential energy increased.
Answer: A
Reference: Section 2.3
Bloom's Taxonomy: Level 3 Application

42) Which of the functional groups below acts like an acid in solution?
A) amino
B) carbonyl
C) carboxyl
D) hydroxyl
Answer: C
Reference: Section 2.3
Bloom's Taxonomy: Level 1 Knowledge

43) You've been asked to analyze a reaction that took place at 300 K. ΔH was -150 and ΔS was +0.4. Is the reaction endothermic or exothermic?
A) endothermic
B) exothermic
C) You cannot tell unless you know the potential energy of the reactants and products.
D) You cannot tell unless you know the amount of disorder in the reactants and products.
Answer: B
Reference: Section 2.3
Bloom's Taxonomy: Level 3 Application

44) The Q10 rule states that within their survivable range the rates of biochemical processes of many ectothermic organisms approximately double with every 10-degree (C) rise in temperature. Why would this be true?
A) Warmer molecules interact faster.
B) There are more vibrational harmonics with greater temperature.
C) Organisms move faster when they are warmer.
D) Sunlight warms all organisms.
Answer: A
Reference: Section 2.3
Bloom's Taxonomy: Level 3 Application

45) Why would the spontaneous formation of formaldehyde and hydrogen cyanide not take place on Earth today as much as on the prebiotic Earth?
A) Microorganisms break these down immediately.
B) The Sun has changed its output.
C) Atmospheric conditions on Earth, such as the presence of oxygen, have changed.
Answer: C
Reference: Section 2.3
Bloom's Taxonomy: Level 1 Knowledge

46) The first chemicals that provided potential energy on Earth may have been formaldehyde and hydrogen cyanide. While these were produced by sunlight-driven reactions, they also occur around deep-sea vents. If the first organisms on Earth evolved around these vents, the first life on Earth was _____.
A) photosynthetic: obtained energy from the Sun
B) chemosynthetic: obtained energy from chemicals
C) herbivorous: obtained energy from plants
D) carnivorous: obtained energy from animals
Answer: B
Reference: Section 2.3
Bloom's Taxonomy: Level 3 Application

47) Which of the following tends to make chemical reactions spontaneous?
A) The reactants have lower potential energy than the products.
B) The reactants are more ordered than the products.
C) The temperature is low.
D) The pressure is low.
Answer: B
Reference: Section 2.3
Bloom's Taxonomy: Level 2 Comprehension

48) Why is carbon so important in biology?
A) It is a common element on Earth.
B) It has very little electronegativity, making it a good electron donor.
C) It bonds to only a few other elements.
D) It forms up to four covalent bonds.
Answer: D
Reference: Section 2.4
Bloom's Taxonomy: Level 1 Knowledge

49) Carbon is an important element for biology because _____.
A) of the variety of carbon skeletons and functional groups that can be built on them
B) it has very high electronegativity and forms highly stable bonds
C) carbon is so rare, organisms conserve it highly
D) it has the ability to form six covalent bonds
Answer: A
Reference: Section 2.4
Bloom's Taxonomy: Level 1 Knowledge

50) _____ atoms give organic molecules their overall shape; _____ atoms determine the overall chemical behavior of organic molecules.
A) Carbon; H, N, and O
B) Hydrogen; C, N, and O
C) Carbon; H_2O
D) H, N, and O; carbon
Answer: A
Reference: Section 2.4
Bloom's Taxonomy: Level 2 Comprehension