

Chapter 2 Water and Carbon: The Chemical Basis of Life
Biological Science, 3e (Freeman)

1) How many electrons are involved in a single covalent bond?

- A) one
- B) two
- C) three
- D) four

Answer: B

Diff: 1

Reference: Section 2.1

Question Type: Factual

Skill/Objective: Recall

Source/Use: Exam

2) How many electrons are involved in a double covalent bond?

- A) one
- B) two
- C) three
- D) four

Answer: D

Diff: 2

Reference: Section 2.1

Question Type: Factual

Skill/Objective: Recall

Source/Use: Exam

3) How many electrons are involved in a triple covalent bond?

- A) two
- B) three
- C) six
- D) nine

Answer: C

Diff: 2

Reference: Section 2.1

Question Type: Factual

Skill/Objective: Recall

Source/Use: Exam

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

Diff: 2

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam

5) If an atom has a charge of -2, which of the following must be true?

- A) It has two more electrons than protons.
- B) It has two more protons than electrons.
- C) It has two more protons than neutrons.
- D) It has two more neutrons than electrons.

Answer: A

Diff: 2

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam

6) If an atom is electrically neutral, which of the following must be true?

- A) It has the same number of protons as neutrons.
- B) It has the same number of protons as electrons.
- C) It has the same number of neutrons as electrons.
- D) It has at least one more electron than it does protons.

Answer: B

Diff: 1

Reference: Section 2.1

Question Type: Recall

Skill/Objective: General

Source/Use: Exam

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

Diff: 2

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam

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

Diff: 2

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam

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

Diff: 2

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam

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

Diff: 2

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam

11) How can you determine the approximate mass of an atom, in atomic mass units?

- A) Add up the number of protons, electrons, and neutrons.
- B) Add up the number of protons and neutrons.
- C) Add up the number of protons and electrons.
- D) Take the number of protons minus the number of electrons.

Answer: B

Diff: 2

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam

12) When one of the atoms involved in a covalent bond has a much higher electronegativity than the other atom, what type of bond results?

- A) a double bond
- B) a hydrogen bond
- C) a nonpolar covalent bond
- D) a polar covalent bond

Answer: D

Diff: 2

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam

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

Diff: 2

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam

14) The difference between a polar covalent bond and an ionic bond is that electrons are shared unequally in a polar covalent bond but completely transferred (i.e., not shared) in an ionic bond.

- A) true

B) false

Answer: A

Explanation: A) This would be a good classroom discussion question to drive home this important but subtle point.

Diff: 2

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 3

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Explanation: B) This question is rather difficult, and easy to misinterpret. Instructors should use it as an exam question only if they have emphasized this concept in class. Otherwise, it would make an excellent in-class question to promote discussion on why certain atoms in molecules have a charge and others do not.

Diff: 3

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 1

Reference: Section 2.1

Question Type: Factual

Skill/Objective: Recall

Source/Use: Exam or In-Class

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

Explanation: D) In-class discussion could be accompanied by pictures of ball-and-stick and space-filling models to stress the advantages of space-filling models.

Diff: 1

Reference: Section 2.1

Question Type: Factual

Skill/Objective: Recall

Source/Use: Exam or In-Class

19) There are four elements that make up 95% of all matter found in organisms. Which of the following is not one of these?

- A) nitrogen
- B) calcium
- C) hydrogen
- D) oxygen

Answer: B

Diff: 1

Reference: Section 2.1

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

20) Why is water capable of forming hydrogen bonds?

- A) The hydrogen atoms carry partial positive charges.
- B) The oxygen atom carries a partial negative charge.
- C) It is highly polar.
- D) All of the above apply.

Answer: D

Diff: 2

Reference: Section 2.2

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

21) Why is water such a good solvent?

- A) Most polar and charged substances dissolve in it.
- B) It is highly polar.
- C) It can participate in hydrogen bonds.
- D) All of the above apply.

Answer: D

Diff: 2

Reference: Section 2.2

Question Type: Factual

Skill/Objective: Recall

Source/Use: Exam or In-Class

22) Which of the following is not a property of liquid water?

- A) Its density is greater than ice.
- B) Its specific heat is higher than that for most other substances.
- C) Its heat of vaporization is lower than that for most other substances.
- D) It is polar.

Answer: C

Diff: 2

Reference: Section 2.2

Question Type: Factual

Skill/Objective: Recall

Source/Use: Exam or In-Class

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 takes a long time to 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

Diff: 2

Reference: Section 2.2

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

24) The ability to sweat or pant is considered an adaptation. Why?

- A) It allows a body to release excess water.
- B) It allows a body to absorb heat, due to water's high specific heat.
- C) It cools a body off, due to water's high heat of vaporization.
- D) It is an important signal to others that an individual is too hot.

Answer: C

Diff: 2

Reference: Section 2.2

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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 saltwater.
- D) Minneapolis is much windier, due to its location in the middle of a continent.

Answer: B

Diff: 1

Reference: Section 2.2

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Explanation: D) This would make a good question for in-class discussion to clarify the difference between specific heat and heat of vaporization. Use on an exam only if the distinction was strongly emphasized in class.

Diff: 3

Reference: Section 2.2

Question Type: Conceptual/Applied

Skill/Objective: Methods and Experimental Design

Source/Use: Exam or In-Class

27) Doctors used to recommend that parents sponge feverish children with rubbing alcohol to lower their body temperature. Rubbing alcohol has a lower heat of vaporization than water does.

Which of the following is true?

A) Rubbing alcohol will evaporate faster than water.

B) Rubbing alcohol will evaporate at the same rate as water.

C) Rubbing alcohol will evaporate more slowly than water.

Answer: A

Diff: 1

Reference: Section 2.2

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Explanation: B) This question appears simple, and is. But the biological importance of bodies of water freezing from the top down, and cells rupturing from inside out due to water freezing, are important and worth noting now.

Diff: 2

Reference: Section 2.2

Question Type: Factual

Skill/Objective: General

Source/Use: Exam or In-Class

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 pH7?

A) 1 in 1 million

B) 1 in 10 million

C) 1 in 100 million

D) 1 in 1 billion

Answer: B

Explanation: B) no other questions on pH, this questions makes student recast the information in different units

Diff: 2

Reference: Section 2.2

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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) 1,000 times

Answer: C

Explanation: C) Introduces log nature of pH scale

Diff: 2

Reference: Section 2.2

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

31) 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 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

Explanation: B) This would be a good question to stimulate discussion on equilibrium and starting dynamics, ratios, and absolute quantities.

Diff: 2

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: Methods and Experimental Design

Source/Use: Exam or In-Class

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

Explanation: D) This question could generate a lot of classroom discussion.

Diff: 3

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Explanation: D) This would be a good Classroom Response System (CRS) question. Wrong answers on this question can be very instructive.

Diff: 3

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 1

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 2

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 2

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 2

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 2

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

39) Why do chemical reactions tend to speed up when the reactants are heated?

- A) The reactants move faster.
- B) The reactants collide more often.
- C) The reactants have greater energy.
- D) All of the above apply.

Answer: D

Diff: 2

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 2

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 1

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

42) Chemical evolution refers to which of the following?

- A) Large molecules tended to break apart because of the intense sunlight and heat from volcanoes.
- B) Water condensed to form the first oceans.
- C) Small molecules reacted to form larger, more complex molecules.
- D) Earth's crust solidified, even as massive bombardment from outer space continued.

Answer: C

Diff: 2

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 2

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: Methods and Experimental Design

Source/Use: Exam or In-Class

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

Diff: 2

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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, have changed, such as the presence of oxygen.

Answer: C

Diff: 3

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 3

Reference: Section 2.3

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 2

Reference: Section 2.4

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 2

Reference: Section 2.4

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

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

Diff: 2

Reference: Section 2.4

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

50) How many times can humans be sure the switch from nonlife to life has happened in the universe?

- A) once
- B) twice
- C) four times
- D) 42 times

Answer: A

Diff: 1

Reference: Section 2.4

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class

51) Many scientific probes sent to other parts of the solar system are looking for signs of something so far known to exist only on Earth, namely _____.

- A) carbon.
- B) gold.
- C) nitrogen.
- D) life.

Answer: D

Diff: 2

Reference: Section 2.4

Question Type: Conceptual/Applied

Skill/Objective: General

Source/Use: Exam or In-Class