1. An atom with three electrons has:
   A) one occupied orbital with three electrons.
   B) two occupied orbitals, one of which has two electrons and the other has one.
   C) three occupied orbitals, each of which contains one electron.
   D) three energy shells, each of which contains one electron.

2. If an atom has three electrons, how many occupied orbitals will the atom have, and how many electrons will be in each?

3. For an atom that is NOT an ion, which of the following must be TRUE?
   A) The number of electrons equals the number of protons.
   B) The number of electrons equals the number of neutrons.
   C) The number of protons equals the number of neutrons.

4. Explain why an atom that is NOT an ion is electrically neutral.

5. Which of the following CORRECTLY pairs the particles of an atom with their physical properties?
   A) proton–positively charged; neutron–uncharged; electron–negatively charged
   B) proton–negatively charged; neutron–uncharged; electron–positively charged
   C) proton–positively charged; neutron–negatively charged; electron–uncharged
   D) proton–uncharged; neutron–negatively charged; electron–positively charged

6. List the particles in an atom, and indicate whether each is positively charged, negatively charged, or uncharged.

7. Sometimes, atoms gain or lose particles. The loss of which of the following results in a change of atomic mass?
   A) a neutron
   B) a proton
   C) an electron
   D) a neutron and a proton
   E) a proton and an electron

8. Sometimes, atoms gain or lose particles. The loss of which of the following would result in a change of overall electrical charge?
   A) protons only
   B) electrons only
   C) neutrons only
   D) protons or neutrons
   E) protons or electrons
   F) neutrons or electrons

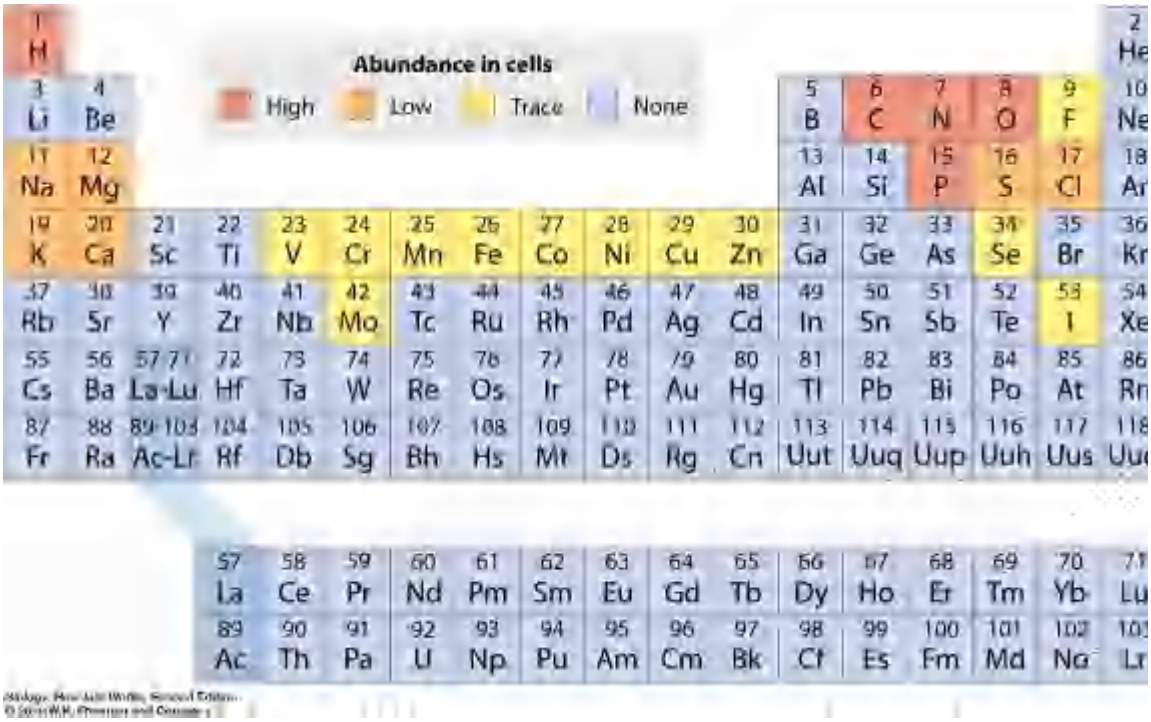
9. The most common isotope of oxygen has 8 protons and an atomic mass of 16. How many neutrons are present in the oxygen nucleus?
   A) 2
   B) 4
   C) 6
   D) 8
   E) 10

10. The most common isotope of oxygen has 8 protons and an atomic mass of 16. How many electrons are present in the orbitals around an atom of oxygen?
   A) 2
   B) 4
   C) 6
   D) 8
   E) 10

11. The most common isotope of oxygen has an atomic mass of 16 (^{16}O). An isotope with an atomic mass of 18 (^{18}O) is also stable. How many valence electrons are present in ^{18}O?
   A) fewer than in ^{16}O
   B) more than in ^{16}O
   C) the same as in ^{16}O
   D) None of the other answer options is correct.

12. ^{14}C is an isotope of carbon that possesses:
   A) 6 protons, 6 neutrons, and 2 electrons.
   B) 6 protons, 8 neutrons, and 6 electrons.
   C) 8 protons, 6 neutrons, and 2 electrons.
   D) 6 protons, 2 neutrons, and 6 electrons.
   E) 6 protons, 8 neutrons, and 2 electrons.

13. Using the periodic table in Fig. 2.3, select the element that would be found in LEAST abundance in a living cell.



A) hydrogen (H)
B) sodium (Na)
C) phosphorous (P)
D) zinc (Zn)
E) silicon (Si)

14. How many electron orbitals does a carbon atom possess?
A) 2
B) 4
C) 5
D) 6
E) 12

15. What differentiates isotopes of the same element?
A) protons
B) neutrons
C) electrons
D) charge

16. You discover an isotope of an element that has 6 electrons in its second and outermost shell, 8 protons, and 6 neutrons. What element is it?
    A) fluorine (F)
    B) carbon (C)
    C) nitrogen (N)
    D) oxygen (O)

17. What would happen to an atom's atomic mass and electric charge if it gained or lost a proton, a neutron, or an electron?

18. The atom:
    A) is the basic unit of matter.
    B) is the unit of composition for elements.
    C) contains protons, neutrons, and electrons.
    D) has negatively charged particles circling around a positively charged nucleus.
    E) All of these choices are correct.

19. The designation of a magnesium ion as Mg^{2+} indicates an atom that has:
    A) two more protons than neutrons.
    B) lost two electrons and is negatively charged.
    C) lost two electrons and is positively charged.
    D) gained two protons and is positively charged.
    E) gained two protons and is negatively charged.

20. The basic unit of matter is referred to as a(n) _____.

21. The negatively charged components of atoms are referred to as:
    A) protons.
    B) electrons.
    C) anions.
    D) neutrons.
    E) cations.

22. For the first three rows of the periodic table, elements in the same row have the same number and type of electron orbitals.
    A) True
    B) False

23. Which one of the following pairs would be classified as isotopes of each other?
    A) H and H^+
    B) Na^+ and Cl^-
    C) C and Si
    D) ^{12}C and ^{13}C
    E) H and H^+, Na^+ and Cl^-, C and Si, ^{12}C and ^{13}C

24. Nitrogen and phosphorus are in the same column of the periodic table. They have similar properties in bonding with other molecules because they have the same number of:
    A) electrons.
    B) paired electrons.
    C) valence electrons.
    D) electron shells.

25. What percentage of carbon's orbitals is spherical in conformation?
    A) 0%
    B) 20%
    C) 40%
    D) 80%
    E) 100%

26. Which one of the following contributes to the measurement referred to as atomic mass?
    A) protons and electrons
    B) electrons and neutrons
    C) protons, electrons, and neutrons
    D) protons and neutrons
    E) neutrons only

27. Which component of an atom has the SMALLEST mass?
    A) proton
    B) neutron
    C) electron
    D) isotope
    E) isomer

28. Two elements within the same group:
    A) occupy the same row on the periodic table of elements.
    B) occupy the same column on the periodic table of elements.
    C) have the same number of electrons in their outermost shell.
    D) have different numbers of electrons in their outermost shell.
    E) occupy the same column on the periodic table and have the same number of electrons in their outermost shell.

29. Consider two carbon atoms, one represented as ^{14}C and the other as ^{12}C. Which of the following statements is TRUE regarding these two atoms?
    A) These carbon atoms have the same number of protons.
    B) These carbon atoms have the same number of neutrons.
    C) These carbon atoms have different numbers of electrons.
    D) These carbon atoms have different numbers of protons.

30. Which of the following statements is TRUE regarding elements?
    A) Elements are composed of several different types of atoms.
    B) Elements are only found in nature and cannot be created by humans.
    C) Elements are still categorized according to Aristotle's early classifications.
    D) Elements are composed of only one type of atom.
    E) Elements are only found in inorganic substances and not in living organisms.

31. Which of the following statements is TRUE regarding atomic mass?
    A) The atomic mass is defined as the sum of electrons and neutrons in an atom.
    B) The atomic mass can be used to differentiate between different isotopes of the same element.
    C) The atomic mass is synonymous with the atomic number.
    D) The atomic mass is calculated by adding the total number of electrons, protons, and neutrons in an atom.

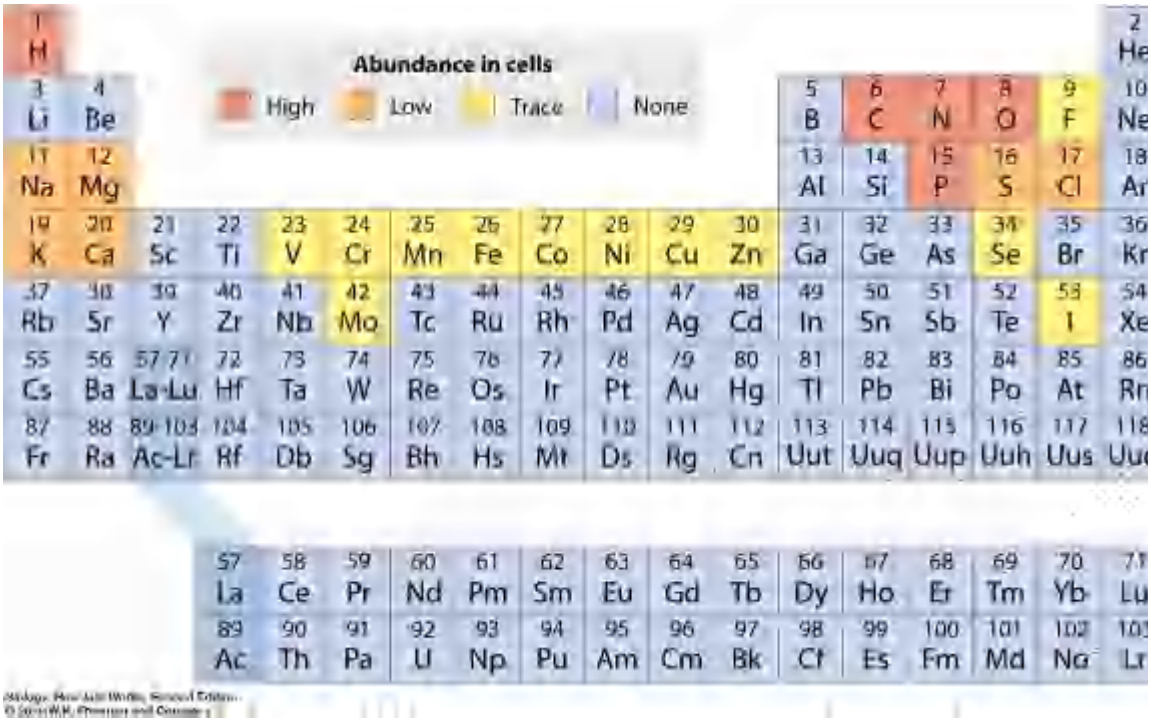
32. Imagine that you have two different carbon atoms, one identified as ^{14}C and the other as ^{13}C. These two carbon atoms:
    A) are two different carbon isotopes.
    B) have a different number of neutrons.
    C) have a different number of protons.
    D) are two different carbon isotopes and have a different number of protons.
    E) are two different carbon isotopes and have a different number of neutrons.

33. Where is the highest-energy electron found in an atom of hydrogen?
    A) in the spherical orbital closest to the nucleus
    B) in the second spherical orbital, a little farther from the nucleus
    C) in the dumbbell-shaped orbital of the y-axis
    D) in the dumbbell-shaped orbital of the x-axis
    E) in the dumbbell-shaped orbital of the z-axis

34. Consider the two elements, sodium (Na) and magnesium (Mg), which occupy the same row in the periodic table of elements. Sodium and magnesium atoms have:
    A) a different number of orbitals.
    B) the same atomic number.
    C) different atomic masses.
    D) the same number of electrons in their outermost orbitals.
    E) different atomic masses and the same number of electrons in their outermost orbitals.

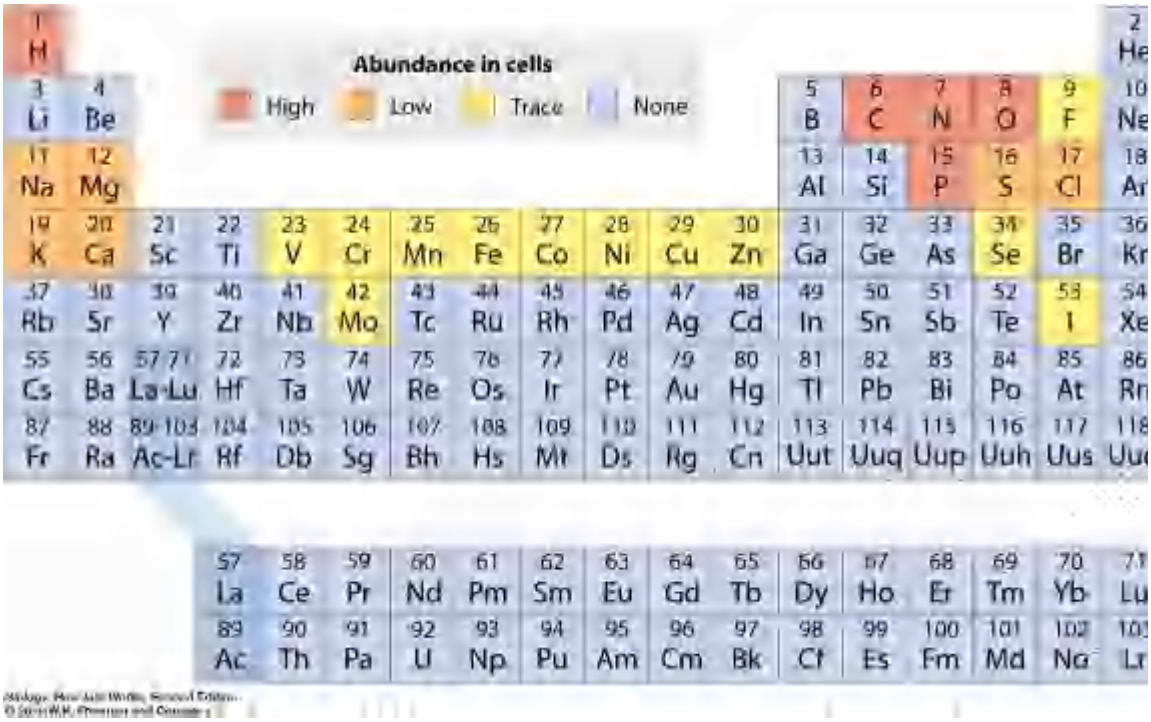
35. Which of the following bonds rely on the attraction of positive and negative charges?
    A) ionic bonds
    B) covalent bonds
    C) hydrogen bonds
    D) ionic bonds and hydrogen bonds
    E) ionic bonds and covalent bonds

36. Refer to the periodic table, and decide which of the following molecules is held together by ionic bonds.



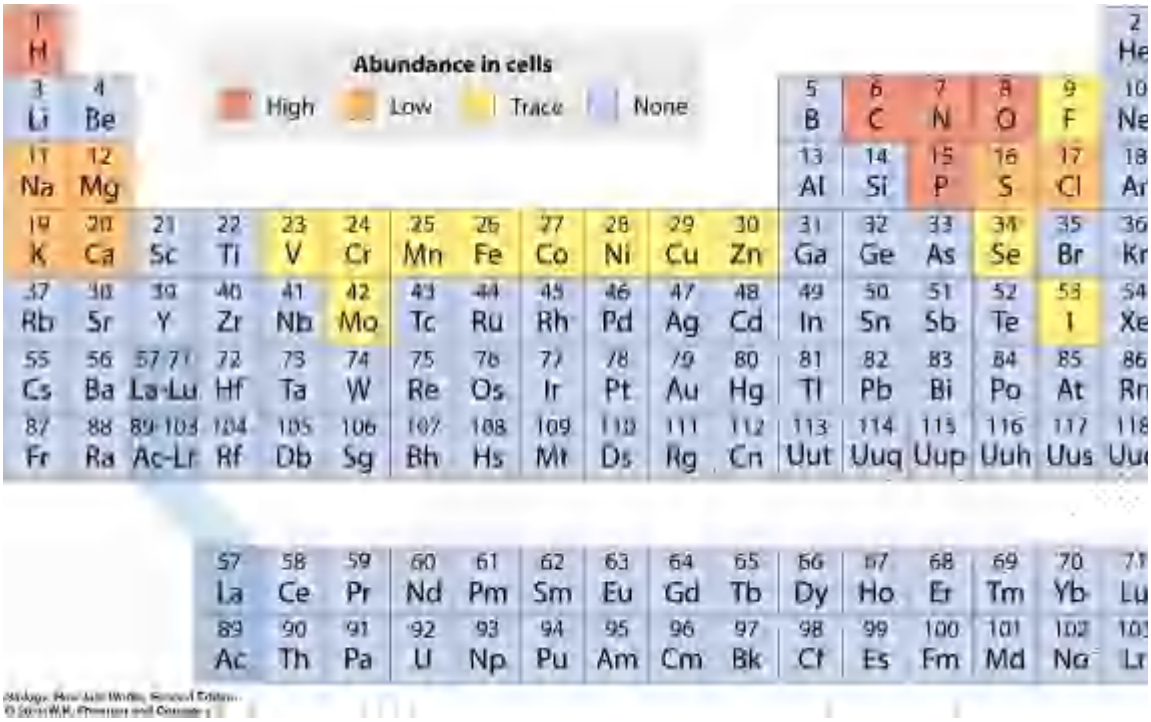
A) NH_3
B) CO_2
C) KCl

37. Refer to the periodic table, and decide which of the following molecules is held together by polar covalent bonds.



A) NH_3
B) CO_2
C) KCl

38. Refer to the periodic table, and decide which of the following molecules is held together by nonpolar covalent bonds.



A) NH_3
B) CO_2
C) KCl

39. Of the following types of bonds between atoms, which is the STRONGEST?
    A) ionic bond
    B) hydrogen bond
    C) covalent bond
    D) van der Waals forces

40. A pair of atoms joined by a polar covalent bond:
    A) has the charge spread evenly across both atoms.
    B) has a slight positive charge on one atom and a slight negative charge on the other.
    C) is unlikely to form hydrogen bonds with water.
    D) mixes well with nonpolar solvents.

41. The ability of atoms to form bonds is due largely to electrons farthest from the nucleus. These electrons are called _____ electrons.

42. Which one of the following elements would MOST likely have bonding properties similar to nitrogen (N)? Consult the periodic table in Fig. 2.3 if necessary.
    A) carbon (C)
    B) silicon (Si)
    C) phosphorus (P)
    D) sulfur (S)
    E) oxygen (O)

43. Which of the following accurately describes a polar covalent bond?
    A) the interaction of a hydrogen atom connected to an atom with a high electronegativity, and an electronegative atom of another molecule
    B) the interaction of an atom with very high electronegativity, and an atom with very low electronegativity
    C) the unequal sharing of electrons between an atom with a partial positive charge, and an atom with a partial negative charge
    D) the equal sharing of electrons between atoms of identical or similar electronegativities
    E) None of the other answer options is correct.

44. Which one of the following is maintained during a chemical reaction?
    A) the number of atoms present in the reactants
    B) the identity of the atoms present in the reactants
    C) the arrangement of chemical bonds present in the reactants
    D) the number and identity of the atoms present in the reactants
    E) the number and identity of the atoms, and the arrangement of chemical bonds present in the reactants.

45. A pair of shared valence electrons is referred to as a(n):
    A) ionic bond.
    B) hydrogen bond.
    C) van der Waals interaction.
    D) covalent bond.
    E) hydrophobic effect.

46. The ability of atoms to attract electrons is referred to as:
    A) van der Waals attraction.
    B) potential energy.
    C) hydrophobicity.
    D) cohesion.
    E) electronegativity.

47. An ionic interaction, such as the interaction between Na^+ and Cl^-, is considered a covalent bond.
    A) True
    B) False

48. A(n) _____ is a substance composed of two or more atoms.

49. The valence electrons of an atom are at the lowest energy level because their increased distance from the nucleus reduces their attraction to the atom's protons.
    A) True
    B) False

50. The _____ of a chemical reaction are transformed into different molecules called _____.
    A) reactants; products
    B) reactants; isomers
    C) products; compounds
    D) products; reactants
    E) compounds; products

51. A polar bond is due to:
    A) equal sharing of valence electrons.
    B) an attraction of opposite charges.
    C) uneven sharing of electrons in a covalent bond.
    D) the interaction between an ion and a non-ionic atom.
    E) None of the other answer options is correct

52. Hydrogen bonding is ultimately due to differences in _____ between two atoms.

53. Which one of the following elements is likely to form exactly three non-ionic interactions with hydrogen?
    A) phosphorus
    B) oxygen
    C) carbon
    D) sulfur
    E) chlorine

54. The structural formula for hydrogen gas (H_2) is represented as H—H. Here, the dash (—) represents a(n):
    A) product.
    B) reactant.
    C) chemical reaction.
    D) chemical bond.
    E) electronegative bond.

55. Which of the following statements regarding an atom with high electronegativity is TRUE?
    A) It will have fewer protons than an atom with low electronegativity.
    B) It will have a tendency not to attract electrons.
    C) It will most likely be located on the left-most side of the periodic table of elements.
    D) None of the other answer options is correct.

56. When two atoms form a covalent bond, they share electrons from all of their orbitals. All of their orbitals, in turn, combine to form a single molecular orbital.
    A) True
    B) False

57. A young girl is staring at the raindrops running down her window. She notices that the raindrops remain more or less intact, even as they cascade down the windowpane. This is a result of:
    A) covalent bonds between water molecules.
    B) oxygen bonds between water molecules.
    C) polar covalent bonds between water molecules.
    D) hydrogen bonds between water molecules.
    E) ionic bonds between water molecules.

58. Which of the following is an example of a hydrogen bond?
    A) the bond that forms between a hydrogen and oxygen atom within the same water molecule
    B) the bond that forms between two hydrogen atoms within the same water molecule
    C) the bond that forms between hydrogen and oxygen atoms within different water molecules
    D) the bond that forms between two hydrogen atoms within different water molecules
    E) the bond that forms between two oxygen atoms within different water molecules

59. A molecule of common table salt, or NaCl, is the result of _____ bond forming between a sodium (Na) atom and a chlorine (Cl) atom.
    A) an ionic
    B) a covalent
    C) a polar covalent
    D) a hydrogen
    E) either an ionic or a polar covalent

60. An ionic bond is really a modified polar covalent bond, because two atoms “share” electrons when one atom steals a valence electron from the other.
    A) True
    B) False

61. A woman's doctor tells her to gargle with salt water. She stirs a tablespoon of salt into a cup of warm water and watches it dissolve. Why does the salt dissolve in water?
    A) The positive hydrogen atoms in water molecules are attracted to chlorine ions.
    B) The positive hydrogen atoms in water molecules are attracted to sodium ions.
    C) The negative oxygen atoms in water molecules are attracted to chlorine ions.
    D) The negative oxygen atoms in water molecules are attracted to sodium ions.
    E) The positive hydrogen atoms in water molecules are attracted to chlorine ions, and the negative oxygen atoms in water molecules are attracted to sodium ions.

62. Part of the reason why salt dissolves in water is that hydrogen bonds form between water molecules and chlorine ions.
    A) True
    B) False

63. What is the chemical basis for water's role as the universal solvent?
    A) Because water is polar, it disrupts most covalent bonds.
    B) Because water is polar, it disrupts hydrogen bonds.
    C) Because water is polar, it disrupts ionic bonds.
    D) Because water is polar, it disrupts both covalent and hydrogen bonds.
    E) Because water is polar, it disrupts both hydrogen and ionic bonds.

64. What is the chemical basis for water's role as the universal solvent?

65. Several chemical properties make water uniquely suited for its role as a central "molecule of life." Which of the following is FALSE?
    A) Hydrogen bonding leads to high cohesiveness between water molecules.
    B) Water resists temperature changes.
    C) Water molecules are always polar.
    D) The structure of a water molecule is stabilized by hydrogen bonds.
    E) Water is a good solvent of polar molecules and ions.

66. Describe three chemical properties of water that make it uniquely suited for its role as a central "molecule of life."

67. The association of individual water molecules with other water molecules is called _____ and occurs through _____ bonds between water molecules.
    A) adhesion; polar covalent
    B) cohesion; polar covalent
    C) cohesion; hydrogen bonds
    D) adhesion; hydrogen bonds

68. The unique properties of water are due to the _____ of water molecules and the ability of water to form _____ with other water molecules and with other polar molecules.
    A) electronegativity; polar covalent bonds
    B) polarity; polar covalent bonds
    C) polarity; hydrogen bonds
    D) hydrophobicity; hydrogen bonds

69. You have an aqueous solution with a pH of exactly 7.0. What would you add to make the solution more acidic?
    A) hydrogen chloride (HCl)
    B) sodium hydroxide (NaOH)
    C) sodium chloride (NaCl)
    D) deionized water (dH_2O)

70. You have an aqueous solution with a pH of 6.0. What would you add to make the solution more basic?
    A) Hydrogen chloride (HCl)
    B) Sodium hydroxide (NaOH)
    C) Sodium chloride (NaCl)
    D) Deionized water (dH_2O)

71. You have an aqueous solution with a pH of 8.0. You add sodium chloride to a concentration of 1 gram per 100 milliliters. What happens to the pH?
    A) It goes up.
    B) It goes down.
    C) It stays the same.
    D) It depends on the temperature.

72. Complete the matching exercise below by choosing the CORRECT description of each bond type in aqueous solution.

    1. covalent bond
    2. hydrogen bond
    3. ionic bond

    A. an interaction of a hydrogen atom and an electronegative atom
    B. an interaction between oppositely charged ions
    C. electrons shared by atoms

73. Complete the matching exercise below by choosing the CORRECT strength of each bond type in aqueous solution. Responses may be used once, more than once, or not at all.

    1. covalent bond in aqueous solution
    2. hydrogen bond in aqueous solution
    3. ionic bond in aqueous solution

    A. weak
    B. strong

74. Which of the following is NOT a property of water?
    A) contracts during freezing
    B) floats when solid
    C) is a good solvent
    D) adheres to polar compounds
    E) is a polar molecule

75. Which statement BEST describes an effect of the low density of frozen water in a lake?
    A) When water freezes, it contracts, decreasing the water level in the lake.
    B) Water in a lake freezes from the bottom up, killing most aquatic organisms.
    C) When water in a lake freezes, it floats, providing insulation for organisms below the ice.
    D) Water removes thermal energy from the land around a lake, causing the lake to freeze.

76. Which one of the following represents the pH of a solution with the HIGHEST concentration of hydrogen ions?
    A) 1.0
    B) 4.5
    C) 7.0
    D) 9.1
    E) 11.5

77. In a solution that has pH = 7.0, the ratio of protons (H^+) to hydroxide ions (OH^-) equals
    A) 70
    B) 7
    C) 1
    D) 1/7
    E) 1/70

78. A water molecule contains what type of bond?
    A) hydrogen
    B) ionic
    C) polar covalent
    D) van der Waals interactions

79. Which of the following statements about water is CORRECT?
    A) Water is the most abundant molecule in living cells.
    B) Water is a polar molecule.
    C) Water has good solvent properties.
    D) Water molecules form hydrogen bonds with other polar molecules.
    E) All of these choices are correct.

80. Which one of the following properties of water is primarily responsible for the ability of trees to draw water up from the roots to the leaves?
    A) polarity
    B) density
    C) solvent capability
    D) cohesion
    E) pH neutrality

81. Water is able to dissolve many compounds as a result of which of the following?
    A) the fact that water molecules are polar
    B) the fact that water molecules are nonpolar
    C) the fact that the hydrogen atoms in water molecules have a slight negative charge
    D) the fact that most nonwater molecules are hydrophobic
    E) the fact that water molecules are polar, and that the hydrogen atoms in water molecules have a slight negative charge

82. Which of the following statements about water is CORRECT?
    A) Ice is less dense than liquid water.
    B) Ice forms on top and sinks to the bottom of lakes and rivers.
    C) Ice is more dense than liquid water.
    D) Bodies of water freeze from the bottom up.
    E) Water molecules in ice demonstrate a disorganized, non-lattice arrangement.

83. Water is neither hydrophilic nor hydrophobic, because these terms only define the interaction of other molecules with water molecules.
    A) True
    B) False

84. Which of the following statements is TRUE regarding a polar molecule?
    A) A polar molecule is hydrophobic.
    B) A polar molecule is hydrophilic.
    C) A polar molecule will dissolve in water.
    D) A polar molecule will not dissolve in water.
    E) A polar molecule is hydrophilic and it will dissolve in water.

85. Imagine you are looking at a bottle of salad dressing containing oil, vinegar, and water. You notice that the oil sits on "top" of the other liquids. This is due, in part, to the fact that:
    A) water is hydrophobic.
    B) oil is hydrophilic.
    C) vinegar is hydrophobic.
    D) oil is hydrophobic.
    E) water is hydrophobic and oil is hydrophilic.

86. A researcher has measured the pH of a solution, and found that the pH is 10. This solution is _____, and has more _____ compared with _____.
    A) basic; protons; hydroxide ions
    B) basic; hydroxide ions; protons
    C) acidic; protons; hydroxide ions
    D) acidic; hydroxide ions; protons
    E) neutral; hydroxide ions; protons

87. Evidence exists that atmospheric CO_2 has increased over the last several decades due to human activities. How do increased CO_2 levels affect the pH of Earth's waters?
    A) It does not affect the pH of Earth's waters, because atmospheric CO_2 is not located in oceans.
    B) Due to the formation of carbonic acid, increased CO_2 levels decrease the pH of Earth's waters.
    C) Due to the formation of carbonic acid, increased CO_2 levels increase the pH of Earth's waters.
    D) Due to the formation of carbonic acid, increased CO_2 levels cause Earth's waters to become neutral.

88. A man heats water in a teakettle while drinking a glass of water at room temperature. The water molecules in the teakettle are moving _____ the water molecules in the glass.
    A) faster than
    B) slower than
    C) at the same speed as

89. As water is heated, the temperature rises before any hydrogen bonds between water molecules are broken.
    A) True
    B) False

90. A man has ordered a glass of soda in a restaurant. When his drink arrives, he notices that quite a bit of ice is floating at the top of the glass. Why does the ice float?
    A) The water molecules in ice are arranged in a lattice pattern, causing ice to float.
    B) The water molecules in the soda are arranged in a lattice pattern, providing a "net" on which ice can sit.
    C) The water molecules in the soda are more densely packed compared to the water molecules in the ice.
    D) The water molecules in the ice are more densely packed compared to the water molecules in the soda.
    E) The water molecules in ice are arranged in a lattice pattern, and the water molecules in the soda are more densely packed compared to the water molecules in the ice, causing ice to float.

91. If hydrogen bonds between water molecules were, collectively, not as strong as they are, how would this affect plant height?
    A) As hydrogen bonds impede the movement of water through plant vasculature, plants would be able to grow taller.
    B) As hydrogen bonds are responsible for the movement of water through plant vasculature, plants would be shorter.
    C) As plants actively transport water through their vasculature, weaker hydrogen bonds would have no effect on plant height.
    D) As hydrogen bonds cause water to stick to the sides of plant vasculature, plants would be able to grow taller.
    E) As hydrogen bonds increase the amount of sugar that plants can transport through their vasculature, plants would be able to grow taller.

92. Water readily dissolves compounds that are referred to as:
    A) hydrophobic.
    B) solvent.
    C) nonpolar.
    D) hydrophilic.
    E) aqueous.

93. The tendency of nonpolar molecules to self-associate in water instead of dissolve individually is called the hydrophobic effect.
    A) True
    B) False

94. Which one of the following statements about pH is INCORRECT?
    A) An acidic solution has a higher concentration of protons than of hydroxide ions.
    B) Physiological pH is defined as the pH of pure water, 7.0.
    C) Some cellular compartments have different pH values than others.
    D) The pH of a solution can range from 0 to 14.
    E) A solution of pH 5 has a proton concentration 100 times greater than a solution of pH 7.

95. Some species of insects are able to walk across liquid water because:
    A) of the high surface tension of water due to the hydrophobic effect.
    B) insects have a low center of gravity.
    C) of the higher density of liquid water compared to solid water.
    D) water has high surface tension due to ionic bonding.
    E) of the high surface tension of water due to its cohesion.

96. Which of the following ranks the elements carbon, sodium, calcium, and iodine in order of decreasing number of electrons?
    A) C□Na□Ca□I
    B) I□Ca□Na□C
    C) I□C□Ca□Na
    D) C□Ca□Na□I

97. Rank the elements carbon, sodium, calcium, and iodine in order of decreasing number of electrons.

98. Which of the following ranks the elements carbon, sodium, calcium, and iodine in order of decreasing abundance in living organisms?
    A) C□a□Ca□I
    B) I□Ca□Na□C
    C) I□C□Ca□Na
    D) C□Ca□Na□I

99. Rank the elements carbon, sodium, calcium, and iodine in order of greatest abundance in living organisms.

100. Rank the elements carbon, phosphorus, calcium, and iodine in order of decreasing number of electrons.
    A) C□P□Ca□I
    B) I□Ca□P□C
    C) I□P□C□Ca
    D) P□C□Ca□I

101. Rank the elements carbon, phosphorus, calcium, and iodine in order of decreasing number of electrons.

102. Rank the elements carbon, phosphorus, calcium, and iodine in order of greatest abundance in living organisms.
    A) P□C□Ca□I
    B) I□Ca□P□C
    C) I□P□C□Ca
    D) C□P□Ca□I

103. Rank the elements carbon, phosphorus, calcium, and iodine in order of greatest abundance in living organisms.

104. Single covalent bonds between carbon atoms:
    A) allow free rotation of the carbon atoms around the bond.
    B) are strong enough to support long chains of carbon atoms.
    C) allow a molecule to twist and turn into many different arrangements.
    D) All of these choices are correct.

105. Three carbon atoms are linked by single covalent bonds such that they form the shape of a V. All of the unshared electrons form covalent bonds with hydrogen. How many hydrogen atoms does this molecule contain?
    A) 2
    B) 4
    C) 6
    D) 8
    E) 10

106. Which of the following ranks the elements carbon, sodium, calcium, and iodine in order of decreasing number of protons?
    A) C□Na□Ca□I
    B) I□Ca□Na□C
    C) I□C□Ca□Na
    D) C□Ca□Na□I

107. Rank the elements carbon, sodium, calcium, and iodine in order of decreasing number of protons.

108. Rank the elements carbon, phosphorus, calcium, and iodine in order of decreasing number of protons.
    A) C□P□Ca□I
    B) I□Ca□P□C
    C) I□P□C□Ca
    D) P□C□Ca□I

109. Rank the elements carbon, phosphorus, calcium, and iodine in order of decreasing number of protons.

110. The structural diversity of carbon-based molecules is determined by which of the following properties?
    A) the ability of carbon to form four covalent bonds
    B) the ability of those bonds to rotate freely
    C) the orientation of those bonds in the form of a tetrahedron
    D) All of these choices are correct.

111. Which one of the following statements about a carbon-carbon double bond is CORRECT?
    A) Each of the two carbons is capable of bonding to three other atoms.
    B) The double bond allows free rotation of the molecule at the bond position.
    C) The double bond is longer than a corresponding carbon-carbon single bond.
    D) Double bonds are often found in cyclical structures.
    E) None of the other answer options is correct.

112. Which of the following CORRECTLY lists the five most abundant elements found in living organisms?
    A) carbon, hydrogen, oxygen, nitrogen, phosphorus
    B) sodium, carbon, oxygen, nitrogen, phosphorus
    C) magnesium, carbon, hydrogen, oxygen, nitrogen
    D) carbon, hydrogen, oxygen, nitrogen, iron

113. List the five most abundant elements found in living organisms. For each of the following, indicate the biologically important molecules in which they are MOST important.

114. Which of the following ranks the elements carbon, sodium, calcium, and iodine in order of decreasing number of valence electrons?
    A) C□Na□Ca□I
    B) I□Ca□Na□C
    C) I□C□Ca□Na
    D) C□Ca□Na□I

115. Rank the elements carbon, sodium, calcium, and iodine in order of decreasing number of valence electrons.

116. Which of the following ranks the elements carbon, sodium, calcium, and iodine in order of decreasing number of energy shells/levels?
    A) C□Na□Ca□I
    B) I□Ca□Na□C
    C) I□C□Ca□Na
    D) C□Ca□N□I

117. Rank the elements carbon, sodium, calcium, and iodine in order of decreasing number of energy shells/levels.

118. Rank the elements carbon, phosphorus, calcium, and iodine in order of decreasing number of valence electrons.
    A) C□P□Ca□I
    B) I□Ca□P□C
    C) I□P□C□Ca
    D) P□C□Ca□I

119. Rank the elements carbon, phosphorus, calcium, and iodine in order of decreasing number of valence electrons.

120. Rank the elements carbon, phosphorus, calcium, and iodine in order of decreasing number of energy shells/levels.
    A) C□P□Ca□I
    B) I□Ca□P□C
    C) I□P□C□Ca
    D) P□C□Ca□I

121. Rank the elements carbon, phosphorus, calcium, and iodine in order of decreasing number of energy shells/levels.

122. Which one of the following elements is found in every organic molecule?
    A) carbon
    B) phosphorus
    C) nitrogen
    D) oxygen
    E) sulfur

123. Isomers are defined as:
    A) elements with the same number of electrons in the outer shell.
    B) molecules with the same chemical formula but different structures.
    C) atoms with the same number of protons but different numbers of neutrons.
    D) molecules with the same general three-dimensional structures but different chemical formulas.
    E) molecules with different chemical formulas but similar biological functions.

124. _____ are molecules with identical chemical formulas but different three-dimensional structures.

125. Organic molecules are those molecules that contain _____.

126. Consider the following two statements about structural representations of molecules, and select the CORRECT response.

1. In a ring structure, an unlabeled atom at the angle where two lines join is assumed to be a carbon atom.
2. Unlabeled atoms joined to carbon atoms, which are not directly part of a ring structure, are assumed to be oxygen atoms.

A) Statements 1 and 2 are both true.
B) Statements 1 and 2 are both false.
C) Statement 1 is true; statement 2 is false.
D) Statement 1 is false; statement 2 is true.

127. Which one of the following statements about carbon is CORRECT?

A) Each of carbon's three valence electrons shares a bond with another atom.
B) Carbon-carbon single bonds allow for free rotation around the bond; carbon-carbon double bonds do not allow for free rotation around the bond.
C) The spatial orientation of carbon's bonds results in a carbon atom resting in the center of a three-dimensional structure referred to as a hexahedron.
D) Carbon is not only the most abundant element on Earth, but it is believed to be the most abundant element in the universe.
E) Single bonds between carbon atoms are typically shorter than double bonds between carbon atoms.

128. Earth's elemental composition is a good reflection of the elemental composition of the universe.

A) True
B) False

129. Humans are often referred to as “carbon-based” life forms. Given that humans breathe oxygen, shouldn't humans be referred to as “oxygen-based” life forms?

A) Yes, because oxygen is the most abundant element in human cells, not carbon.
B) Yes, because humans inhale oxygen.
C) No, because carbon is the most abundant element in human cells, not oxygen.
D) No, because humans exhale carbon dioxide.
E) No, because oxygen is not an organic molecule.

130. Recall that a carbon atom behaves as if it possesses four valence electrons. Given this information, what is the MOST likely structural formula for carbon dioxide (CO_2)?
    A) O□C□O
    B) O=C=O
    C) O=C□O
    D) O□C=O

131. What unique property of carbon enables this element to be “life's chemical backbone”?
    A) Carbon can form double bonds.
    B) Carbon has four electrons.
    C) Carbon behaves as if it has four valence electrons.
    D) Carbon can form double or single bonds.
    E) Carbon is the most abundant element in the universe.

132. Could silicon-based life ever exist within the universe?
    A) Yes, although it is unlikely given the interaction between silicon and oxygen.
    B) Yes, because silicon is in the same family as carbon, and these elements have similar properties.
    C) No, because silicon has a different atomic number than carbon, and these elements have dissimilar properties.
    D) No, because silicon is remarkably rare in the universe.
    E) Yes, because silicon is in the same family as carbon, and these elements have similar properties, although it is unlikely given the interaction between silicon and oxygen.

133. Imagine that you have a (simplified) structural diagram of an organic molecule depicted as \ /\ /\ /\ , with no letters included. What can you deduce?
    A) The molecule is composed of carbon only.
    B) The molecule is composed of hydrogen only.
    C) The molecule may contain any element and needs to be labeled.
    D) The molecule contains only carbon and hydrogen.
    E) The molecule contains only oxygen and carbon.

134. Which of the following molecules is classified as an organic molecule?
    A) NH_3 (ammonia)
    B) H_2O (water)
    C) NaCl (sodium chloride or salt)
    D) O_2 (oxygen gas)
    E) None of the other answer options is correct.

135. An organic molecule MUST contain which of the following elements?
    A) oxygen
    B) helium
    C) carbon
    D) nitrogen
    E) phosphorous

136. Recall that isoleucine and leucine can both be written as $C_6H_{13}O_2N_1$; however, the structures of these two molecules are not identical (Fig. 2.16). Thus, isoleucine and leucine are:
    A) polar molecules.
    B) isotopes.
    C) isomers.
    D) reactants.
    E) proteins.

137. Which of the following statements is TRUE regarding carbon?
    A) Carbon atoms can only form single covalent bonds with other carbon atoms.
    B) Double bonds that form between carbon atoms are only found in "ring" molecules.
    C) Isomers of carbon-containing compounds always have the same structure but different chemical formulas.
    D) When a carbon atom forms a molecule, it acquires four dumbbell-shaped orbitals.
    E) None of the other answer options is correct.

138. Imagine that a few centuries from now, scientists discover life on a new planet. This life will MOST likely be based on:
    A) silicon.
    B) magnesium.
    C) oxygen.
    D) carbon.
    E) None of the other answer options is correct.

139. Because of hydrogen bonding, water is uniquely suited for its central role in life. Many hydrophilic molecules interact freely with water, but a number of hydrophobic molecules are important for life, too. How does the interaction between water and hydrophobic molecules help to organize biological systems?
    A) Because cells are not pure water (they have many substances dissolved within them), the hydrophilic/hydrophobic effect has a limited role in biological organization.
    B) The ionic bonds between water molecules cause hydrophobic molecules to associate with each other and not with water molecules.
    C) Because water molecules preferentially associate with each other, they force hydrophobic molecules to associate with each other and not with water molecules.
    D) None of the other answer options is correct.

140. How does the interaction between water and hydrophobic molecules help to organize biological systems?

141. Which of the following are covalent bonds?
    A) peptide bonds
    B) glycosidic bonds
    C) phosphodiester bonds
    D) All of these choices are correct.

142. Name the specific types of bonds that hold the monomers together in proteins, nucleic acids, and complex carbohydrates.

143. In general, colder temperatures reduce the fluidity of the membrane, so cells will produce different molecules to maintain the proper degree of fluidity. How would the membrane change in response to colder temperatures?
    A) The amount of saturated triacylglycerols would increase.
    B) The amount of unsaturated fatty acids would increase.
    C) The length of the fatty acid side chains in the phospholipids would increase.
    D) The amount of unsaturated fatty acids would decrease.
    E) The amount of saturated triacylglycerols would decrease.

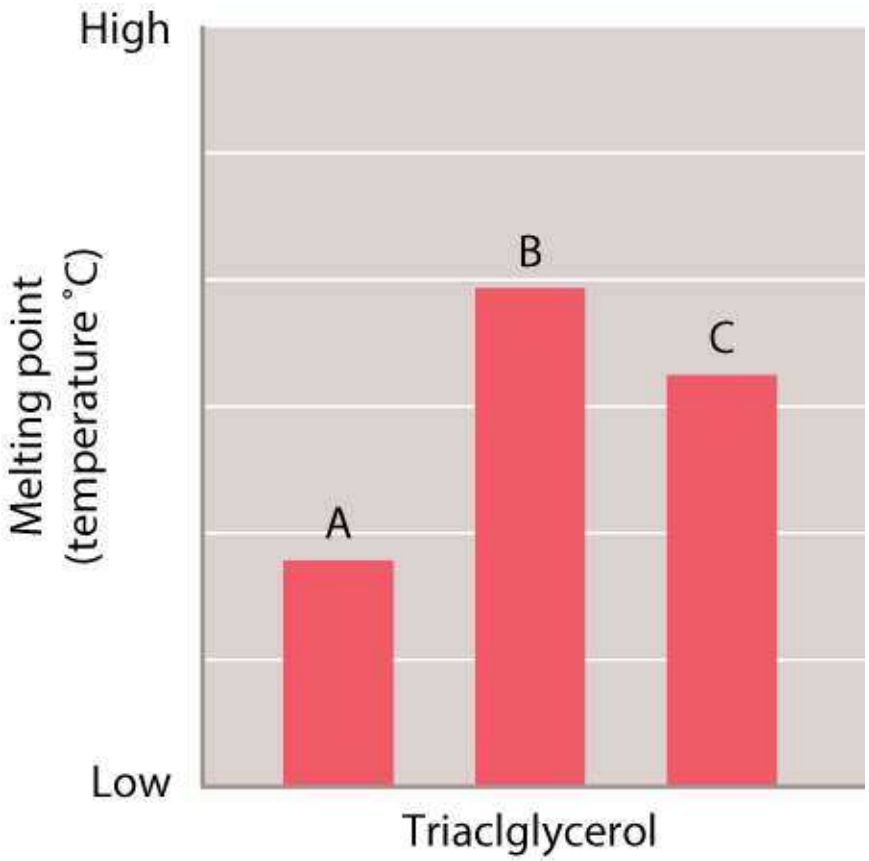
144. If a cell is placed in a cooler environment, the fluidity of the membrane can decrease. What change could the cell make in the membrane composition to restore the normal level of fluidity?

145. Consider the structure and function of DNA. Which of the following statements is TRUE?
    A) Because DNA contains carbohydrates, it provides structural support to the cells.
    B) The phosphodiester bonds that stabilize the association of the two strands are easily broken and reformed.
    C) If the sequence of one DNA strand is known, then the sequence of the other strand can be determined.
    D) Because DNA is made of phosphate groups that are ionized, it could easily pass through a cell membrane.

146. If one strand of the DNA double helix is known, explain how the other strand can be determined.

147. In DNA molecules, complementary base pairs always include one purine nucleotide and one pyrimidine nucleotide. In the DNA of certain bacterial cells, 16% of the nucleotides are adenine nucleotides. What are the percentages of the other nucleotides in the bacterial DNA?
    A) 16% thymine, 34% guanine, 34% cytosine
    B) 34% uracil, 16% guanine, 16% cytosine
    C) 34% thymine, 34% guanine, 16% cytosine
    D) 34% thymine, 16% guanine, 34% cytosine
    E) None of the other answer options is correct.

148. Samples of three different triacylglycerols were tested to determine the melting point of each one. The results of the tests are shown in the graph.



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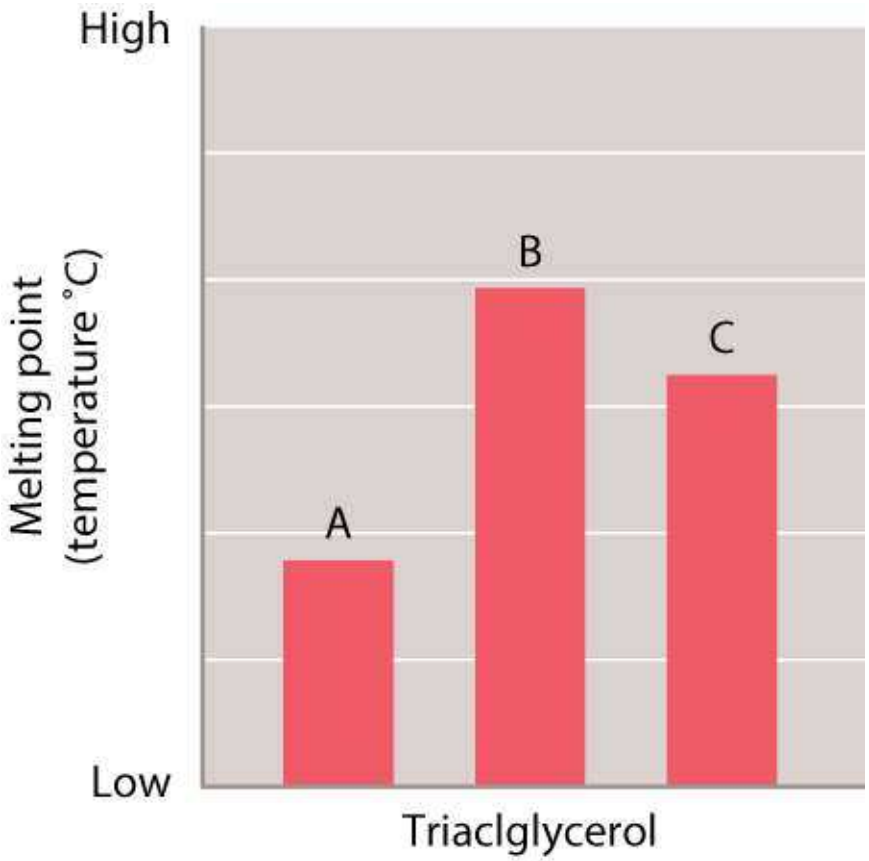
The length of the fatty acids A, B, and C is the same. Which of the three triacylgcerols is likely to have the MOST double bonds in the fatty acids?

A) A
B) B
C) C
D) There is no way of knowing based on the information available.

149. Samples of three different triacylglycerols were tested to determine the melting point of each one. The results of the tests are shown in the graph.



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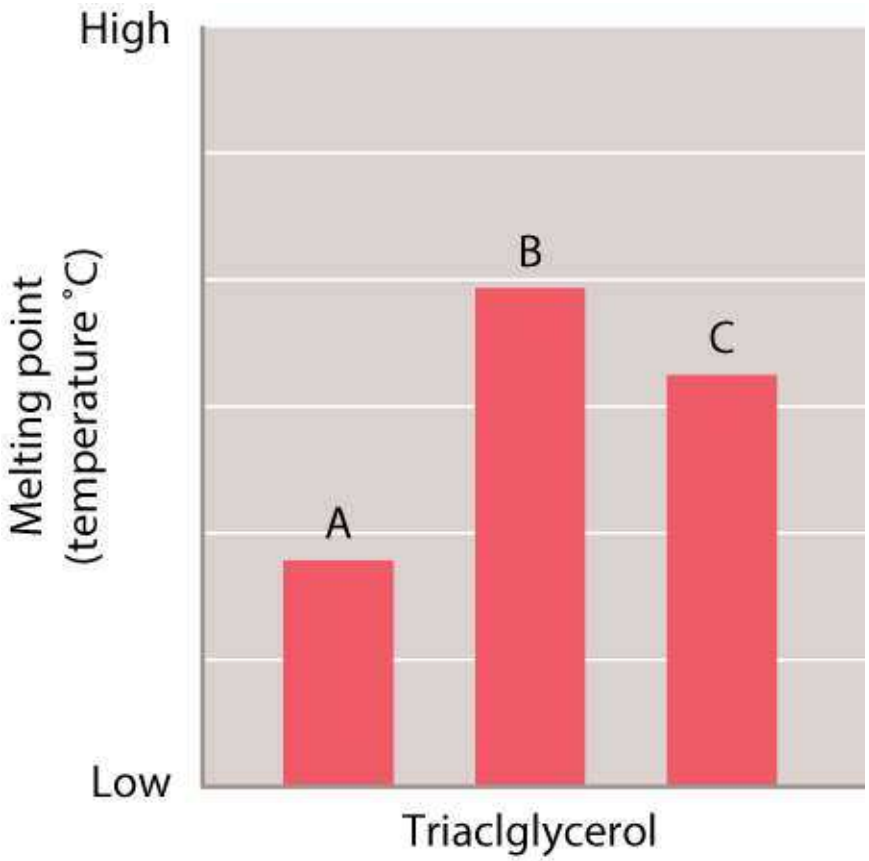
The length of the fatty acids in A, B, and C is the same. Which of the three triacylgcerols is likely to have the FEWEST number double bonds in the fatty acids?

A) A
B) B
C) C
D) There is no way of knowing based on the information available.

150. Samples of three different triacylglycerols were tested to determine the melting point of each one. The results of the tests are shown in the graph.



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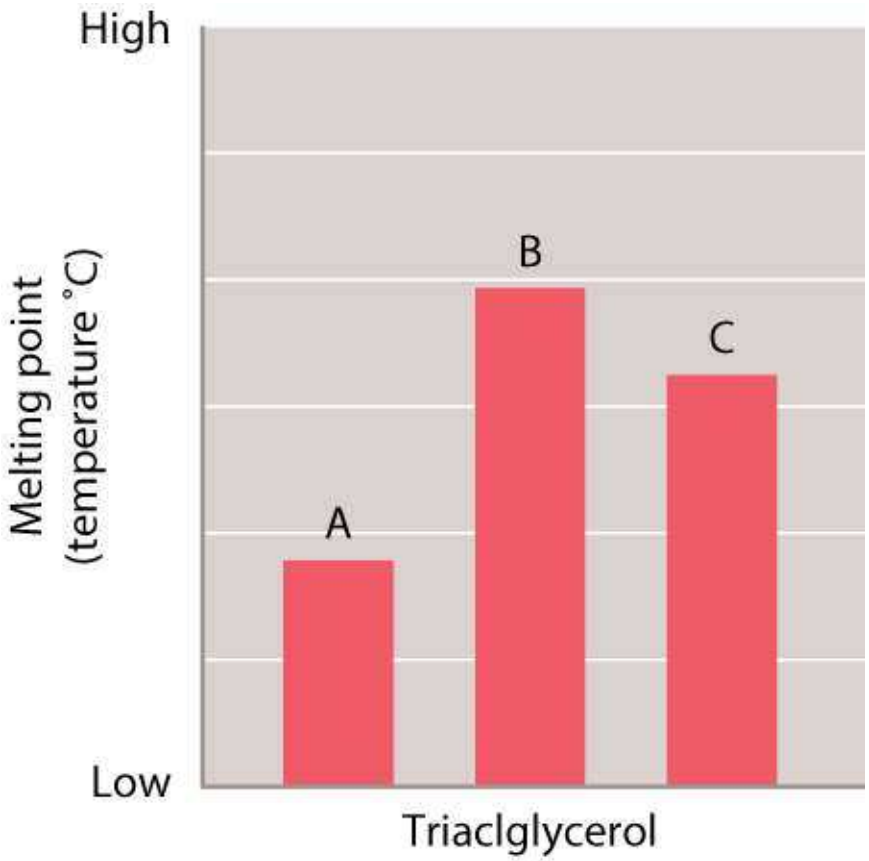
The length of the fatty acids in A, B, and C is the same. Which of the three fatty acids is likely to have the MOST saturated fatty acids?

A) A
B) B
C) C
D) There is no way of knowing based on the information available.

151. Samples of three different triacylglycerols were tested to determine the melting point of each one. The results of the tests are shown in the graph.



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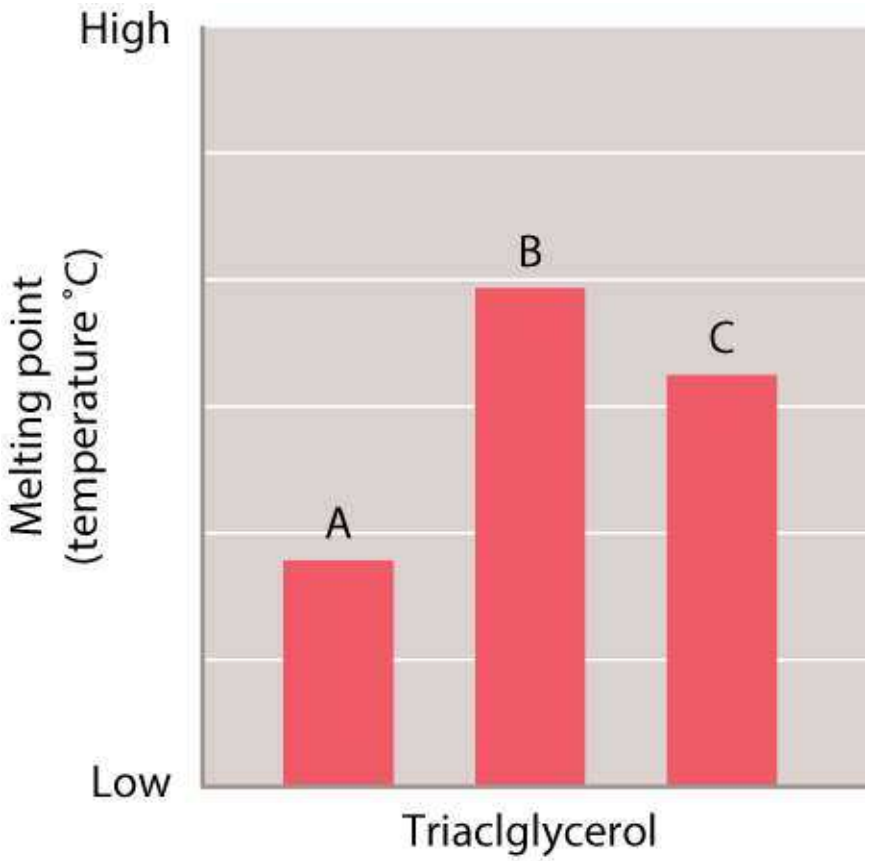
The length of the fatty acids in A, B, and C is the same. Which of the three fatty acids is likely to have the MOST unsaturated fatty acids?

A) A
B) B
C) C
D) There is no way of knowing based on the information available.

152. Samples of three different triacylglycerols were tested to determine the melting point of each one. The results of the tests are shown in the graph.



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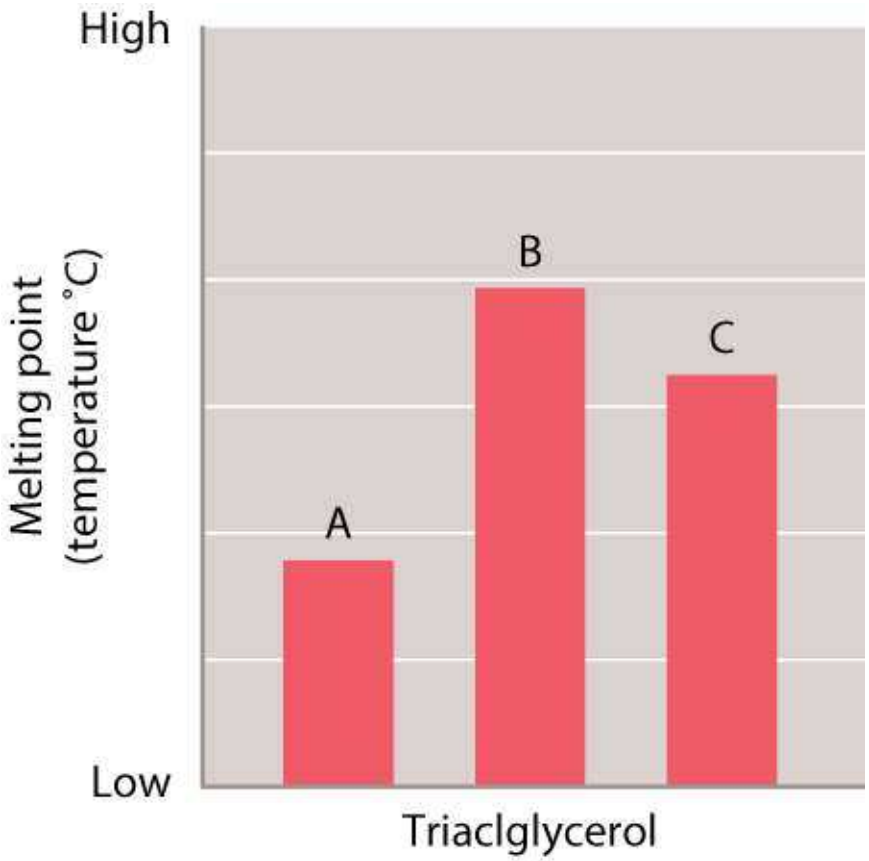
The number of double bonds in each of the fatty acids A, B, and C is the same. Which of the three triacylgcerols is likely to have the fatty acids with the LONGEST hydrocarbon chains?

A) A
B) B
C) C
D) There is no way of knowing based on the information available.

153. Samples of three different triacylglycerols were tested to determine the melting point of each one. The results of the tests are shown in the graph.



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The number of double bonds in each of the fatty acids in A, B, and C is the same. Which of the three triacylgcerols is likely to have the fatty acids with the SHORTEST hydrocarbon chains?

A) A
B) B
C) C
D) There is no way of knowing based on the information available.

154. How many hydrogen atoms are present in a hydrocarbon chain of five carbon atoms with one double bond and the rest single bonds?

A) 6
B) 8
C) 10
D) 12

155. How many hydrogen atoms are present in a hydrocarbon chain of five carbon atoms with two double bonds and two single bonds?
    A) 6
    B) 8
    C) 10
    D) 12

156. How many hydrogen atoms are present in a five-carbon hydrocarbon molecule with four of the carbons linked by a single covalent bond, and with the fifth carbon attached by a single bond as a branch to the second carbon in the chain?
    A) 6
    B) 8
    C) 10
    D) 12

157. How many hydrogen atoms are present in a ring of six carbon atoms held together by alternating single and double bonds?
    A) 6
    B) 8
    C) 10
    D) 12

158. What important feature(s) of noncovalent bonds make(s) them so important to life?
    A) They are strong in a cellular environment that holds atoms together tightly.
    B) They are weak in a cellular environment, so they can be made, broken, and reformed easily.
    C) They can only occur in cells.
    D) None of the other answer options is correct.

159. What important feature(s) of noncovalent bonds make(s) them so important to life?

160. Peptide bonds are characteristic of:
    A) nucleic acids.
    B) carbohydrates.
    C) lipids.
    D) fatty acids.
    E) proteins.

161. Pyrimidine and purine bases are found in:
    A) nucleic acids.
    B) carbohydrates.
    C) lipids.
    D) fatty acids.
    E) proteins.

162. Aldoses and ketoses are examples of:
    A) nucleic acids.
    B) carbohydrates.
    C) lipids.
    D) fatty acids.
    E) proteins.

163. An unsaturated fatty acid contains:
    A) only carbon and hydrogen.
    B) only single covalent bonds between carbon atoms.
    C) one or more double bonds between carbon atoms.
    D) one or more double bonds between hydrogen atoms.

164. A phosphodiester bond is formed between:
    A) a fatty acid and a glycerol molecule.
    B) two amino acids.
    C) a base and a sugar.
    D) a 3' phosphate and a 5' hydroxyl group.
    E) a 5' phosphate and a 3' hydroxyl group.

165. Which one of the following components of an amino acid differs from one amino acid to another?
    A) the □-carbon atom
    B) the carboxyl group
    C) the side chain
    D) the amino group
    E) the hydrogen atom opposite the R group

166. A How many hydrogen atoms are present in a hydrocarbon chain of five carbons joined to each other by single covalent bonds?
    A) 6
    B) 8
    C) 10
    D) 12

167. How many hydrogen atoms are present in a hydrocarbon chain of eight carbon atoms with three double bonds and the rest single bonds?
    A) 10
    B) 12
    C) 14
    D) 16

168. Which one of the following is a pyrimidine found in DNA?
    A) adenine
    B) guanine
    C) uracil
    D) thymine
    E) None of the other answer options is correct

169. _____ are the subunits of nucleic acids, and _____ are the subunits of proteins.
    A) Nucleotides; amino acids
    B) Bases; polypeptides
    C) Polypeptides; sugars
    D) Amino acids; nucleic bases
    E) Nucleoli; amino acids

170. Carbohydrates and proteins are two types of macromolecules. Which functional characteristic of proteins distinguishes them from carbohydrates?
    A) tendency to make cell membranes hydrophobic
    B) efficient storage of usable chemical energy
    C) ability to catalyze biochemical reactions
    D) large amount of stored information
    E) None of the other answer options is correct.

171. Which one of the following MOST accurately describes the ratio of oxygen to carbon to hydrogen in a simple 6-carbon sugar such as glucose?
    A) 1:2:1
    B) 1:1:2
    C) 2:1:1
    D) 1:2:3
    E) 1:3:2

172. Sucrose is composed of:
    A) two ketose sugars.
    B) a six-carbon sugar and a five-carbon sugar.
    C) a simple sugar and a nucleotide.
    D) an aldose and a ketose.
    E) glycerol and three fatty acids.

173. Which one of the following biological polymers is defined by a physical property instead of a chemical structure?
    A) proteins
    B) lipids
    C) monosaccharides
    D) nucleic acids
    E) polysaccharides

174. Which one of the following types of fatty acids would be likely to have the LOWEST melting temperature?
    A) long tails and low saturation
    B) long tails and high saturation
    C) short tails and low saturation
    D) short tails and high saturation
    E) All fatty acids have the same melting temperature, regardless of tail length or level of saturation.

175. Which one of the following types of fatty acids would be likely to participate in the HIGHEST number of van der Waals forces with other fatty acids? Fatty acids with:
    A) long tails and low saturation.
    B) long tails and high saturation.
    C) short tails and low saturation.
    D) short tails and high saturation.

176. Helicase is an enzyme that separates the double helix of the DNA into two separate strands. How do you think helicase does this?
    A) by breaking hydrogen bonds
    B) by breaking phosphodiester bonds
    C) by breaking peptide bonds
    D) by breaking ionic bonds

177. You spill a little bit of olive oil on your hands. You wash off the oil with soap and water. How does the soap get the oil off your hands?
    A) The hydrophilic part of soap interacts with the oil and sequesters it.
    B) The hydrophobic part of soap interacts with the oil and sequesters it.
    C) The soap dissolves the oil.
    D) The soap makes the water and oil interact in such a way that it dissolves the oil.

178. Two of the main ingredients in plant fertilizer are phosphorus and nitrogen. These elements are required for the synthesis of _____ in the cells of the plants.
    A) DNA and proteins
    B) proteins and complex carbohydrates
    C) complex carbohydrates and DNA

179. Two of the main ingredients in most plant fertilizers are phosphorus and nitrogen. Why are these elements so important for the growth of a plant?

180. As part of their normal function, many proteins bind to DNA briefly and then release it again. Which types of bonds might be involved in these transient protein-DNA interactions? (Select all that apply.)
    A) hydrogen
    B) ionic
    C) covalent
    D) van der Waals forces

181. Which types of bonds might be involved in the following: DNA double helix, folding of a protein, protein binding to DNA, protein-protein interactions?

182. Based on your knowledge of the different sorts of bonds in biological systems, describe some cellular structures or interactions that rely upon those bonds. Consider all the different bonds and as many specific examples as you can.

183. Recall the stalactite-like slime formations oozing from cave walls in the case “The First Cell: Life's Origin” just before Chapter 2. The slimy bits hanging from the cave surface are secretions from the extremophile bacteria that live in this unusual environment and are composed of water, acids, and mucous secretions. What types of chemical bonds are likely to anchor and stabilize these long, slender strands found hanging in the caves?
    A) nonpolar covalent bonds and hydrogen bonds
    B) hydrogen bonds
    C) hydrogen bonds and disulfide bridges
    D) polar covalent bonds and hydrogen bonds

184. Recall the stalactite-like slime formations oozing from cave walls in the case “The First Cell: Life's Origin” at the beginning of Chapter 2. The slimy bits hanging from the cave surface are secretions from the extremophile bacteria that live in this unusual environment and are composed of water, acids, and mucous secretions. How might hydrogen bonding hold the snottites together?

185. Although monosaccharides can exist in linear form, virtually all cellular monosaccharides are found in circular form.
    A) True
    B) False

186. The linkage of one amino acid to another amino acid in a protein is referred to as a(n):
    A) peptide bond.
    B) glycosidic bond.
    C) ionic bond.
    D) R group.
    E) phosphodiester bond.

187. Triacylglycerols are used primarily for:
    A) energy storage.
    B) information storage.
    C) cell membrane biosynthesis.
    D) biological catalysis.
    E) movement.

188. The class of organic molecules defined by a physical property instead of a structure is the:
    A) lipids.
    B) carbohydrates.
    C) proteins.
    D) nucleic acids.
    E) None of the other answer options is correct.

189. The covalent linkage joining two amino acids together is referred to as a(n) _____ bond.

190. Adjacent nucleotides in an RNA chain are held together by hydrogen bonding.
    A) True
    B) False

191. Monosaccharides with an aldehyde group in their linear form are referred to as aldoses.
    A) True
    B) False

192. Fatty acids that contain no carbon-carbon double bonds are referred to as _____.

193. Oils are triacylglycerols with a high level of unsaturated fatty acids.
    A) True
    B) False

194. Which one of the following is NOT a component of an amino acid?
    A) an alpha carbon
    B) an amino group
    C) a carboxyl group
    D) an R group
    E) a phosphate group

195. Which one of the following nucleotides could base pair with a pyrimidine?
    A) uracil
    B) cytosine
    C) adenine
    D) thymine
    E) All of these choices are correct.

196. The formation of which one of the following large organic molecules from their respective building blocks does NOT result in the release of at least one water molecule?
    A) proteins
    B) phospholipids
    C) polysaccharides
    D) nucleic acids
    E) All of these choices are correct.

197. Monosaccharides can be found in linear form, but in living organisms are much more commonly found in cyclic form.
    A) True
    B) False

198. Which one of the following is NOT a component of a phospholipid?
    A) a 3-carbon backbone such as glycerol
    B) a phosphate group
    C) two fatty acid tails
    D) a core of four fused carbon rings
    E) All of these choices are correct.

199. Which of the following organic molecules is commonly used for energy storage?
    A) proteins and nucleic acids
    B) lipids and carbohydrates
    C) nucleic acids and lipids
    D) carbohydrates, nucleic acids, and lipids
    E) proteins, carbohydrates, and lipids

200. Lipid bilayers spontaneously form to orient the _____ tails _____ to minimize their contact with water.
    A) hydrophilic; outside
    B) hydrophilic; inside
    C) hydrophobic; outside
    D) hydrophobic; inside

201. With four distinct nucleotides, how many combinations are possible in a sequence of six nucleotides?
    A) 24
    B) 64
    C) 1296
    D) 4096
    E) 64,000,000

202. A 1,4-glycosidic linkage would refer to which one of the following?
    A) hydrogen bonding between carbon 1 and carbon 4 within a monosaccharide
    B) the covalent bond between the 1□ carbon of one nucleotide and the 4□ carbon of a second nucleotide
    C) the covalent bond between amino acid 1 in one protein and amino acid 4 in a second protein
    D) hydrogen bonding among the four bases in double-stranded DNA
    E) the covalent bond between carbon 1 of one monosaccharide and carbon 4 of a second monosaccharide

203. Based on what the chapter describes about the melting temperature of fatty acids, which of the following would be likely to INCREASE the stability of a lipid bilayer?
    A) an increase in unsaturated fatty acids
    B) an increase in saturated fatty acids
    C) a decrease in overall tail length
    D) an increase in unsaturated fatty acids and an increase in saturated fatty acids
    E) an increase in saturated fatty acids and a decrease in overall tail length

204. Which of the following would NOT be true of the first life forms on Earth, that is, the very first primitive cells?
    A) Oxygen was required for the cells to survive.
    B) A molecule evolved as a way to store genetic information.
    C) A barrier made of organic molecules separated the “cell” from the environment.
    D) Chemical reactions evolved as a way for cells to capture energy from the environment.

205. Describe the three important features that would be necessary to classify the first primitive cells as true cells.

206. If you isolate a single nucleotide from a nucleic acid chain and determine that the nitrogenous ring structure is cytosine, you could say with certainty that the nucleotide may have come from:
    A) DNA but not RNA.
    B) RNA but not DNA.
    C) either DNA or RNA.
    D) neither DNA nor RNA.
    E) double-stranded DNA but not single-stranded DNA.

207. Miller and Urey's initial simulation resulted in the formation of which one of the following?
    A) DNA
    B) glucose
    C) RNA
    D) phospholipids
    E) amino acids

208. Certain meteorites have been examined and found to carry samples of which one of the following?
    A) lipids
    B) amino acids
    C) polypeptides
    D) lipids and amino acids
    E) lipids, amino acids, and polypeptides

209. Sutherland and colleagues demonstrated the synthesis of which one of the following under conditions thought to resemble those of early Earth?
    A) nucleotides
    B) amino acids
    C) phospholipids
    D) nucleic acid chains
    E) polypeptides

210. Imagine you were there when Stanley Miller performed his experiment to produce the building blocks of life. If Miller originally identified 5 different amino acids, how many polypeptides that are 10 amino acids long could be made from just these 5 amino acids?
    A) $5 \times 10 = 50$
    B) $10^5 = 100{,}000$
    C) $5^{10} = 9{,}765, 625$
    D) The answer cannot be determined from the information provided.

211. Calculate the number of different polypeptides, each 10 amino acids long, that can be made if you start with just 5 different kinds of amino acids.

212. The snottites described in the case “The First Cell: Life's Origin” at the beginning of Chapter 2 are colonies of bacteria, which are extremophiles that have some unique requirements for life processes. For example, they use sulfur from the hydrogen sulfide in the environment to capture energy. Although most life forms that are familiar to you, including humans, don't use sulfur for this purpose, we do use another element to do the same thing. Which element do humans use for this energy conversion? Carefully examine the periodic table.
    A) carbon
    B) nitrogen
    C) hydrogen
    D) oxygen

213. The snottites described in “The First Cell: Life's Origin” just before Chapter 2 are colonies of bacteria, which are extremophiles that have some unique requirements for life processes. For example, they use sulfur from the hydrogen sulfide in the environment to capture energy. Although most life forms that are familiar to you, including humans, don't use sulfur for this purpose, we do use another element to do the same thing. Using the periodic table, explain how some elements could substitute for others in biochemical reactions. For example, science fiction writers sometimes speculate that there could be silicon-based life forms on other planets, and some extremophiles on Earth, such as the snottites, use sulfur in a similar manner to how humans use oxygen.

214. Studies of the origin of life on Earth help us to consider what would be required for life elsewhere in the universe. Which of the following is MOST likely to be true of extraterrestrial life?
    A) Carbon will act as the backbone for organic molecules.
    B) Light from a nearby star will make photosynthesis possible.
    C) Oxygen will be used to convert energy in cells.
    D) Water will not be required to sustain life.

215. As we look for life elsewhere, we expect it to be different from life on Earth. However, scientists predict it will be carbon-based and it will require water. Explain why.

216. Would the first cells most likely have used DNA as their genetic (information storage) molecule?
    A) yes
    B) no

217. Explain why DNA was probably NOT the genetic (information storage) molecule for the first cells.

218. The cells that arose on early Earth from primordial reactions are strikingly similar to animal cells of today.
    A) True
    B) False

219. Which one of the following gases was NOT a component of the simulated atmosphere in the Miller-Urey experiment?
    A) hydrogen
    B) water vapor
    C) oxygen
    D) methane
    E) ammonia

220. Amino acids can be spontaneously generated in vitro, but only under anaerobic conditions.
    A) True
    B) False

221. Experiments generating simple molecules under conditions resembling that of early Earth demonstrate that the first cells are likely to be extremely similar to cells found today.
    A) True
    B) False

222. It is believed that the surfaces upon which the first nucleic acids were able to form were made of:
    A) limestone.
    B) clay.
    C) granite.
    D) diamond.
    E) sand.

223. The age of the Earth is 4.6 billion years. For what percentage of this time is Earth thought to have been anaerobic?
    A) 0.1%
    B) 27%
    C) 44%
    D) 68%
    E) 99.3

224. The bacteria found in present-day oceans closely resemble those that existed in Earth's early history.
    A) True
    B) False

225. Which of the following statements is TRUE regarding Leslie Orgel's experiments?
    A) This work provided insight into how the first nucleotides may have formed on Earth.
    B) This work provided insight into how the first nucleic acids may have formed on Earth.
    C) This work provided insight into how the first amino acids formed on Earth.
    D) This work provided insight into how the first proteins formed on Earth.

226. During his experiments, Stanley Miller was able to re-create many of the amino acids found in organisms, but also some not found in organisms.
    A) True
    B) False

227. Imagine an Earth where no life is present, but that has an atmosphere and oceans that are identical to those that exist today. If lightning strikes, would you predict that life would form on this alternate Earth?
    A) Yes, because present-day oxygen levels in Earth's atmosphere would be conducive to the formation of amino acids.
    B) Yes, because present-day oxygen levels in Earth's atmosphere would be conducive to the formations of nucleotides.
    C) No, because oxygen levels on present-day Earth are much lower compared to those on early Earth, and would not be conducive to the formation of amino acids.
    D) No, because oxygen levels on present-day Earth are much higher compared to those on early Earth, and would not be conducive to the formation of amino acids.

228. Which of the following was required for early life to form on Earth?
    A) low oxygen conditions, which allowed for the formation of amino acids
    B) clay, which allowed for the formation of nucleic acids
    C) phosphates, which allowed for the formation of nucleotides
    D) the presence of hydrogen, which allowed for the formation of amino acids
    E) All of these choices are correct.

229. Imagine that scientists are examining a meteorite that has crashed into Earth. Which of the following might the researchers find within the meteorite?
    A) carbon-containing molecules
    B) amino acids
    C) lipids
    D) All of these choices are correct.
    E) None of the other answer options is correct.

230. Which of the following gases did Stanley Miller NOT use in his experiment to recapitulate the Earth's early atmosphere?
    A) oxygen gas (O_2)
    B) water vapor (H_2O)
    C) ammonia (NH_3)
    D) hydrogen gas (H_2)
    E) methane (CH_4)

231. Stanley Miller's research provided insight into how the first proteins may have appeared on Earth.
    A) True
    B) False

232. Fossils provide evidence detailing how early nucleic acids and proteins first appeared on Earth. The work of Stanley Miller, Leslie Orgel, and John Sutherland recapitulated events depicted in the fossil record.
    A) True
    B) False

233. Which of the following statements is TRUE regarding nucleic acids?
    A) Nucleic acids cannot form spontaneously; the first nucleic acids were most likely "built" by early proteins.
    B) Nucleic acids can form spontaneously, provided that an adequate number of nucleotides are available.
    C) Early nucleic acids were likely formed spontaneously and could not have formed complementary strands.
    D) None of the other answer options is correct.

234. Scientists only understand how the first amino acids and nucleic acids formed on Earth; researchers have no theories as to how early sugars were produced.
    A) True
    B) False

Answer Key

1. B
2. The atom will have two orbitals. One will have two paired electrons, and the other will have one unpaired electron.
3. A
4. In an atom that is not an ion, the number of positively charged protons always equals the number of negatively charged electrons.
5. A
6. proton–positively charged; neutron–uncharged; electron–negatively charged
7. D
8. E
9. D
10. D
11. C
12. B
13. E
14. C
15. B
16. D
17. If an atom:

    gained a proton, its atomic mass would increase and its electrical charge would become more positive.

    lost a proton, its atomic mass would decrease and its electrical charge would become more negative.

    gained a neutron, its atomic mass would increase and its electrical charge would remain the same.

    lost a neutron, its atomic mass would decrease and its electrical charge would remain the same.

    gained an electron, its atomic mass would remain essentially the same and its electrical charge would become more negative.

    lost an electron, its atomic mass would remain essentially the same and its electrical charge would become more positive.
18. E
19. C
20. atom
21. B
22. A
23. D
24. C

25. C
26. D
27. C
28. E
29. A
30. D
31. B
32. E
33. A
34. C
35. D
36. C
37. A
38. B
39. C
40. B
41. valence
42. C
43. C
44. D
45. D
46. E
47. B
48. molecule
49. B
50. A
51. C
52. electronegativity
53. A
54. D
55. D
56. B
57. D
58. C
59. A
60. B
61. E
62. A
63. E
64. Because water is polar, it disrupts hydrogen and ionic bonds in and between other molecules.
65. D
66. 1) Water is a polar molecule that forms hydrogen bonds between water molecules (cohesion) and between water molecules and other polar molecules (adhesion). 2) The high frequency of hydrogen bonding between water molecules resists changes in temperature. 3) The polarity of water molecules is responsible for their ability to act as a

good solvent of ions and other polar molecules.

67. C
68. C
69. A
70. B
71. C
72. 1 = C; 2 = A; 3 = B
73. 1 = B; 2 = A; 3 = A
74. A
75. C
76. A
77. C
78. C
79. E
80. D
81. A
82. A
83. B
84. E
85. D
86. B
87. B
88. A
89. B
90. E
91. B
92. D
93. A
94. B
95. E
96. B
97. I, Ca, Na, C
98. D
99. C, Ca, Na, I
100. B
101. I□Ca□P□C
102. D
103. C□P□Ca□I
104. D
105. D
106. B
107. I, Ca, Na, C
108. B
109. I□Ca□P□C
110. D
111. D

112. A
113. carbon – all macromolecules
hydrogen – all macromolecules
oxygen – all macromolecules
nitrogen – proteins and nucleic acids
phosphorus – nucleic acids and some lipids (phospholipids)
114. C
115. I, C, Ca, Na
116. B
117. I, Ca, Na, C
118. C
119. I□P□C□Ca
120. B
121. I□Ca□P□C
122. A
123. B
124. Isomers
125. carbon
126. C
127. B
128. B
129. C
130. B
131. C
132. E
133. D
134. E
135. C
136. C
137. E
138. D
139. C
140. Because water molecules preferentially associate with each other, they force hydrophobic molecules to associate with each other and not with water molecules.
141. D
142. Proteins are made of amino acids covalently bonded, with peptide bonds between the carboxyl group of one amino acid and the amino group of the next amino acid.

Nucleic acids are made of nucleotides connected via phosphodiester bonds between the sugar and phosphate groups of adjacent nucleotides.

Carbohydrates are made from monosaccharide subunits connected via glycosidic bonds between a carbon on one monosaccharide and a hydroxyl group on the other.
143. B
144. The cell could increase the amount of unsaturated fatty acids in the phospholipid bilayer. Because these molecules have a bend in the chain, fewer van der Waals forces

can form between them, and the cell membrane will become less rigid and more fluid.

145. C
146. Because the strands are held together via hydrogen bonding of the base pairs, and the pairing is always the same (A with T and G with C), then by applying the complementary base-pairing rules, one can determine the complementary strand of a known strand. For example, if the one strand is AAGCTTG, then the complement will be TTCGAAC.
147. A
148. A
149. B
150. B
151. A
152. B
153. A
154. C
155. B
156. D
157. A
158. B
159. They are weak in a cellular environment so they can be made, broken, and reformed easily.
160. E
161. A
162. B
163. C
164. E
165. C
166. D
167. B
168. D
169. A
170. C
171. B
172. D
173. B
174. C
175. B
176. A
177. B
178. A
179. Phosphorus is required for nucleic acid synthesis, and nitrogen is required for both nucleic acid and protein synthesis.
180. A, B, D
181. DNA double helix–covalent (phosphodiester) and hydrogen. Folding of a protein–covalent (disulfide bridge), hydrogen and ionic bonds and van der Waals forces. Protein binding to DNA–hydrogen and ionic bonds. Protein-protein

interaction–hydrogen and ionic bonds and van der Waals forces.

182. Examples:
DNA – hydrogen bonds help hold the helix together
Protein folding – hydrogen bonds and ionic bonds
Enzyme-substrate interactions – mostly noncovalent interactions of multiple types
Molecular structure – covalent bonds hold atoms together tightly for membrane integrity
Thermophilic bacteria – extensive covalent bonds in proteins to stabilize shape
183. B
184. The snottites are held together by hydrogen bonding. Hydrogen bonding occurs between water molecules, between water molecules and other components of the snottite, and between water molecules and the rock surface.
185. A
186. A
187. A
188. A
189. peptide
190. B
191. A
192. saturated
193. A
194. E
195. C
196. E
197. A
198. D
199. B
200. D
201. D
202. E
203. B
204. A
205. 1) A molecule, such as a nucleic acid, that can act as an information storage system; 2) a barrier (i.e., a lipid membrane) to encapsulate the cell and separate it from the environment; 3) biochemical reactions and pathways to meet the energy requirements of the cell.
206. C
207. E
208. D
209. A
210. C
211. Any of the 5 amino acids could occupy any of the positions in the 10 amino acid long chain, creating

$5 \times 5 \times 5 \times 5 \times 5 \times 5 \times 5 \times 5 \times 5 \times 5 = 5^{10}$, or 9,765,625, possible different polypeptide chains
212. D

213. Based on their position in the periodic table, we know that many elements have similar properties, particularly with regard to their bonding behaviors. If two elements appear in the same column in the periodic table, they tend to interact with other elements in the same way. Thus, because silicon can form four bonds with other atoms, some speculate it could substitute for carbon. Oxygen and sulfur each require two electrons to make a full octet (and are very electronegative), so they behave similarly—both can be used in energy conversion reactions.
214. A
215. Carbon is very versatile in the number of molecules that it can create, particularly given its bonding properties. Water's unique properties, from resisting temperature changes to cohesion to loss of density when frozen, make it an important medium for life on this planet, so it's hard to imagine any life existing in its absence.
216. B
217. DNA is a very complex molecule, which is unlikely to have been the first molecule to evolve for this function. In addition, as we'll see in later chapters, DNA relies on proteins to function, and proteins rely on DNA to encode their sequences. These two systems are unlikely to have evolved simultaneously. Thus, it is more likely that another molecule, maybe RNA (which has information storage and catalytic properties), or something before that, was the first genetic molecule.
218. B
219. C
220. A
221. B
222. B
223. C
224. B
225. B
226. A
227. D
228. E
229. D
230. A
231. A
232. B
233. B
234. B