Chapter 02
The Chemical Basis of Life I: Atoms, Molecules, and Water

Multiple Choice Questions

1. The atomic number of an atom is
A. the number of protons in the atom.
B. the number of neutrons in the atom.
C. the number of protons and electrons in the atom.
D. the number of protons and neutrons in the atom.
E. None of these choices are correct.

Blooms Level: 1. Remember
LO: 02.01.03 Relate atomic structure to the periodic table of the elements.
Section: 02.01 Atoms
Topic: Atoms

2. The smallest functional unit and associated structures of a living organism are
A. atoms and their protons, neutrons and electrons.
B. molecules and their atoms, bonds and electrons.
C. proteins and amino acids.
D. cells with nucleus, mitochondria and ER.
E. water made of hydrogen and oxygen.

Blooms Level: 1. Remember
Gradable: automatic
LO: 02.01.01 Describe the general structure of atoms and their constituent particles.
Section: 02.01 Atoms
Topic: Atoms

Check All That Apply Questions

3. With an atomic mass of 16 and an atomic number of 8, it follows that oxygen
__X__ has eight electrons.
_____ has 16 neutrons.
__X__ can readily form bonds with 2 other atoms.
_____ weighs 16 grams.

Blooms Level: 2. Understand
LO: 02.01.03 Relate atomic structure to the periodic table of the elements.
Section: 02.01 Atoms
Topic: Atoms

Multiple Choice Questions

4. The nucleus of an atom is composed of
A. protons.
B. neutrons.
C. electrons.
D. protons and neutrons.
E. protons and electrons.

Blooms Level: 1. Remember
LO: 02.01.01 Describe the general structure of atoms and their constituent particles.
Section: 02.01 Atoms
Topic: Atoms

5. The first, inner-most energy shell of an atom
A. can have a maximum of 8 electrons.
B. can have a maximum of 2 electrons.
C. is called the 2p orbital.
D. is called the 1s orbital and can have a maximum of 8 electrons.
E. is called the 2p orbital and can have a maximum of 2 electrons.

Blooms Level: 1. Remember
LO: 02.01.02 Discuss the way electrons occupy electron shells that surround the nucleus.
Section: 02.01 Atoms
Topic: Atoms

6. Tritiated hydrogen (^3H) differs from hydrogen (^1H) in that
A. ^3H has 2 more protons than ^1H.
B. ^3H has 2 more electrons than ^1H.
C. ^3H has 2 more neutrons than ^1H.
D. ^3H has the same number of neutrons as ^1H.
E. ^3H has a different electron configuration than ^1H.

Blooms Level: 2. Understand
LO: 02.01.05 Explain how a single element may exist in more than one form, called isotopes.
Section: 02.01 Atoms
Topic: Atoms

7. Isotopes are different forms of the same element that
A. differ in their number of neutrons.
B. differ in their number of protons.
C. are all produced artificially.
D. cannot form covalent bonds.
E. cannot form ions.

Blooms Level: 2. Understand
LO: 02.01.05 Explain how a single element may exist in more than one form, called isotopes.
Section: 02.01 Atoms
Topic: Atoms

8. The element found in most abundance in living organisms is
A. calcium.
B. iron.
C. iodine.
D. hydrogen.
E. sodium.

Blooms Level: 2. Understand
LO: 02.01.06 List the elements that make up most of the mass of all living organisms.
Section: 02.01 Atoms
Topic: Atoms

9. Nitrogen has 7 electrons and can form a maximum of _____ bonds with other elements.
A. 1
B. 2
C. 3
D. 4
E. 5

Blooms Level: 2. Understand
LO: 02.02.01 Compare and contrast the types of atomic interactions that lead to the formation of molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

10. Molecules
A. are derived from the ionic bonding of two or more atoms.
B. have the same physical properties as the atoms from which they were derived.
C. are not important in biological processes.
D. can form from the covalent bonding of two or more atoms.
E. cannot have a charge.

Blooms Level: 2. Understand
LO: 02.02.01 Compare and contrast the types of atomic interactions that lead to the formation of molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

11. Carbon has 4 electrons and hydrogen has 1 electron in its outermost electron shell. A carbon atom can form covalent bonds with how many hydrogen atoms?
A. 0
B. 1
C. 2
D. 3
E. 4

Blooms Level: 3. Apply
LO: 02.01.02 Discuss the way electrons occupy electron shells that surround the nucleus.
Section: 02.01 Atoms
Topic: Atoms

12. When one atom loses an electron to another atom, it results in the formation of
A. a polar covalent bond and a new molecule.
B. cations and anions that can form ionic bonds.
C. a covalent bond between the two.
D. many hydrogen bonds.
E. a nonpolar covalent bond that is difficult to break.

Blooms Level: 2. Understand
LO: 02.02.01 Compare and contrast the types of atomic interactions that lead to the formation of molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

13. The strongest chemical bonds are
A. hydrogen bonds.
B. Van der Waal forces.
C. hydrophobic interactions.
D. ionic bonds.
E. covalent bonds.

Blooms Level: 1. Remember
LO: 02.02.01 Compare and contrast the types of atomic interactions that lead to the formation of molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

14. What type of bonding is likely to occur between two water molecules or strands of DNA?

A. covalent
B. ionic
C. hydrogen
D. both hydrogen and covalent
E. both hydrogen and ionic

Blooms Level: 2. Understand
LO: 02.02.01 Compare and contrast the types of atomic interactions that lead to the formation of molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

15. Carbon and hydrogen have similar electronegativities and combine together to form hydrocarbon molecules. What type of bonds form between these atoms?
A. hydrogen
B. ionic
C. polar covalent
D. nonpolar covalent
E. electrostatic

Blooms Level: 2. Understand
LO: 02.02.02 Explain the concept of electronegativity and how it contributes to the formation of polar and nonpolar covalent bonds.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

16. What type of bonds form from the unequal sharing of electrons?
A. hydrogen
B. ionic
C. polar covalent
D. nonpolar covalent
E. electrostatic

Blooms Level: 2. Understand
LO: 02.02.01 Compare and contrast the types of atomic interactions that lead to the formation of molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

17. In water, $MgCl_2$ dissociates into Mg^{2+} and Cl^-. Based on this information what type of bond is involved in the formation of $MgCl_2$?
A. hydrogen
B. ionic
C. polar covalent
D. nonpolar covalent
E. electrostatic

Blooms Level: 3. Apply
LO: 02.02.01 Compare and contrast the types of atomic interactions that lead to the formation of molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

18. When one oxygen atom shares two pairs of electrons with another oxygen atom, O_2 is formed via a(n)
A. single covalent bond.
B. double covalent bond.
C. triple covalent bond.
D. ionic bond.
E. hydrogen bond.

Blooms Level: 2. Understand
LO: 02.02.01 Compare and contrast the types of atomic interactions that lead to the formation of molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

19. The most hydrophilic substance is
A. water.
B. an ion.
C. oil.
D. an amphipathic molecule.
E. a gas.

Blooms Level: 5. Evaluate
Gradable: automatic
LO: 02.04.02 List the properties of water that make it a good solvent, and distinguish between hydrophilic and hydrophobic substances.
Section: 02.04 Properties of Water

20. Amphipathic molecules
A. possess only hydrophilic properties.
B. possess only hydrophobic properties.
C. possess both hydrophilic and hydrophobic properties.
D. possess neither hydrophilic nor hydrophobic properties.
E. tend not to interact with other molecules.

Blooms Level: 1. Remember
LO: 02.04.02 List the properties of water that make it a good solvent, and distinguish between hydrophilic and hydrophobic substances.
Section: 02.04 Properties of Water

21. For water to vaporize
A. energy must be supplied.
B. energy must be released.
C. hydrogen bonds are broken.
D. both energy must be supplied and hydrogen bonds broken.
E. both energy must be released and hydrogen bonds broken.

Blooms Level: 2. Understand
LO: 02.04.01 Describe how hydrogen bonding determines many properties of water.
Section: 02.04 Properties of Water

22. The molarity of a solution is
A. a measure of solute concentration.
B. the weight of a solid substance.
C. often expressed as grams per unit volume.
D. reflects a measure of the amount of oil dissolved in water.
E. a scientific term for determining the solubility of a substance in water.

Blooms Level: 1. Remember
LO: 02.04.03 Explain how the molarity of a solution—the number of moles of a solute per liter of solution—is used to measure the concentration of solutes in solution.
Section: 02.04 Properties of Water

23. Based on the colligative properties of water, what would happen if one were to add a solute to water?
A. The freezing point of water would decrease.
B. The freezing point of water would increase.
C. The boiling point of water would increase.
D. Both the freezing point of water would decrease and the boiling point of water would increase.
E. Nothing would change with respect to the freezing point or boiling point of water.

Blooms Level: 3. Apply
LO: 02.04.04 Discuss the properties of water that are critical for the survival of living organisms.
Section: 02.04 Properties of Water

24. Water
A. is nonpolar.
B. has a low heat of vaporization.
C. has cohesive properties.
D. evaporates and increases body temperature.
E. is a relatively poor solvent.

Blooms Level: 2. Understand
LO: 02.04.04 Discuss the properties of water that are critical for the survival of living organisms.
Section: 02.04 Properties of Water

25. If orange juice has a pH of 4 then it can be described as
A. having a H^+ concentration is 4.
B. an acidic solution.
C. an alkaline solution.
D. an acidic solution with a H^+ concentration of 4.
E. None of these choices are correct.

Blooms Level: 2. Understand
Gradable: automatic
LO: 02.05.01 Explain how water has the ability to ionize into hydroxide ions (OH-) and into hydrogen ions (H), and how the H concentration is expressed as a solution's pH.
Section: 02.05 pH and Buffers
Topic: pH and Buffers

26. A significant role played by pH buffers is to
A. prevent fluctuations in the acidity of solutions.
B. increase the strength of acids and bases.
C. prevent fluctuations in the salinity of solutions.
D. limit major shifts in the amount of H^+ and OH^- in solution.
E. keep pH low.

Blooms Level: 2. Understand
Gradable: automatic
LO: 02.05.02 Give examples of how buffers maintain a stable environment in an animal's body fluids.
Section: 02.05 pH and Buffers
Topic: pH and Buffers

27. If a person ingested a can of soda with a pH of 3, the body would work to maintain homeostasis by
A. increasing the amount of H^+ in an acidic solution.
B. reducing the amount of H^+ in an acidic solution.
C. reducing the amount of H^+ in an alkaline solution.
D. increasing the amount of OH^- ions in an alkaline solution.
E. reducing the amount of OH^- in an acidic solution.

Blooms Level: 3. Apply
Gradable: automatic
LO: 02.05.02 Give examples of how buffers maintain a stable environment in an animal's body fluids.
Section: 02.05 pH and Buffers
Topic: pH and Buffers

28. The addition of a strong acid like HCl to an aqueous solution would result in
A. the release of H^+ into the solution.
B. an increase in pH.
C. a decrease in pH.
D. both the release of H^+ and an increase in pH.
E. both the release of H^+ and a decrease in pH.

Blooms Level: 4. Analyze
Gradable: automatic
LO: 02.05.01 Explain how water has the ability to ionize into hydroxide ions (OH-) and into hydrogen ions (H), and how the H concentration is expressed as a solution's pH.
Section: 02.05 pH and Buffers
Topic: pH and Buffers

True / False Questions

29. One gram of hydrogen, which has an atomic mass of 1, would have fewer atoms than 1 gram of carbon that has an atomic mass of 12.
FALSE

Blooms Level: 3. Apply
LO: 02.01.04 Quantify atomic mass using units such as daltons and moles.
Section: 02.01 Atoms
Topic: Atoms

30. Isotopes are different forms of the same element.
TRUE

Blooms Level: 2. Understand
LO: 02.01.05 Explain how a single element may exist in more than one form, called isotopes.
Section: 02.01 Atoms
Topic: Atoms

31. Sulfur 35 (^{35}S) is an isotope of ^{32}S. These elements differ in their number of neutrons.
TRUE

Blooms Level: 2. Understand
LO: 02.01.05 Explain how a single element may exist in more than one form, called isotopes.
Section: 02.01 Atoms
Topic: Atoms

32. Helium is an inert gas that rarely reacts with other elements because it has the maximum number of valence electrons in its outer shell.
TRUE

Blooms Level: 2. Understand
LO: 02.01.02 Discuss the way electrons occupy electron shells that surround the nucleus.
Section: 02.01 Atoms
Topic: Atoms

33. If lithium has an atomic number of 3 then it will have 1 valence electron.
TRUE

Blooms Level: 2. Understand
LO: 02.01.03 Relate atomic structure to the periodic table of the elements.
Section: 02.01 Atoms
Topic: Atoms

34. The electronegativity of an atom is a measure of its ability to attract electrons to its outer shell from another atom.
TRUE

Blooms Level: 2. Understand
LO: 02.02.02 Explain the concept of electronegativity and how it contributes to the formation of polar and nonpolar covalent bonds.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

35. Table salt forms from sodium and chloride via hydrogen bonding.
FALSE

Blooms Level: 2. Understand
LO: 02.02.01 Compare and contrast the types of atomic interactions that lead to the formation of molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

36. Molecules are generally rigid structures and rarely change shape.
FALSE

Blooms Level: 2. Understand
LO: 02.02.03 Describe how a molecule's shape is important for its ability to interact with other molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

37. A dehydration reaction that builds larger molecules from smaller units requires the addition of a water molecule.
FALSE

Blooms Level: 2. Understand
LO: 02.04.04 Discuss the properties of water that are critical for the survival of living organisms.
Section: 02.04 Properties of Water

38. The hydroxyl (OH^-) concentration of a solution with a pH of 8 would be 10^{-6} molar.
TRUE

Blooms Level: 3. Apply
LO: 02.05.01 Explain how water has the ability to ionize into hydroxide ions (OH-) and into hydrogen ions (H), and how the H concentration is expressed as a solution's pH.
Section: 02.05 pH and Buffers
Topic: pH and Buffers

39. Most enzymes or bioactive molecules work effectively within a broad range of pH.
FALSE

Blooms Level: 2. Understand
General LO: Compare relative scales of biological structures and processes.
Gradable: automatic
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

Multiple Choice Questions

40. $Zn + 2H^+ = Zn2^+ + H_2$ is an example of a redox reaction. What is happening during this interaction? Is a bond created between the atoms during this reaction?
A. Oxidation reaction and acceptance of an electron; bond is formed.
B. Reduction reaction and acceptance of an electron; no bond is formed.
C. Reduction reaction and donation of an electron; no bond is formed.
D. Covalent interaction; bond is formed.

Blooms Level: 4. Analyze
LO: 02.02.01 Compare and contrast the types of atomic interactions that lead to the formation of molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules
Type: Quantitative Reasoning

41. You notice that the majority of the electrons in NaCl spend their time around the chlorine. You also notice that the electrons in H_2 are evenly distributed among the two atoms. Which two types of bonds are represented in these molecules?
A. Covalent bonds in NaCl; ionic bonds in H_2.
B. Covalent bonds in NaCl; covalent bonds in H_2.
C. Ionic bonds in NaCl; ionic bonds in H_2.
D. Ionic bonds in NaCl; covalent bonds in H_2.

Blooms Level: 3. Apply
Gradable: automatic
LO: 02.02.02 Explain the concept of electronegativity and how it contributes to the formation of polar and nonpolar covalent bonds.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

42. A bottle of Na in solution and a bottle of Cl in solution are mixed together. What type of bond will be created between the atoms, and what will be the product?
A. Covalent bonds; sodium chlorine
B. Ionic bonds; table salt
C. Hydrogen bonds; sodium hydroxide
D. Carbon bonds; carboxyl groups

Blooms Level: 3. Apply
LO: 02.02.01 Compare and contrast the types of atomic interactions that lead to the formation of molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

43. You've been asked to stabilize a compound whose general state is altered by excess electrons. The element you would add to the compound to most effectively stabilize the compound would be? Why?
A. Carbon, because it is capable of neutralizing electrons.
B. Nitrogen, because it has five electrons on its outer shell.
C. Fluorine, because it is the greediest atom on the periodic table.
D. Oxygen, because it can easily bind with the compound.

Blooms Level: 5. Evaluate
Gradable: automatic
LO: 02.03.01 Relate the concept of a chemical reaction to the concept of chemical equilibrium.
Section: 02.03 Chemical Reactions
Topic: Chemical Reactions

44. You want to simulate the production of carbon dioxide (CO_2) in a laboratory setting using carbon and oxygen atoms. What type of reactions do you need to facilitate in order to create CO_2?
A. An oxidation, or the gain of an electron, and a reduction, or the loss of an electron.
B. An oxidation, or the loss and electron, and a reduction, or the loss of an electron.
C. An oxidation, or the gain of an electron, and a reduction, or the gain of electron.
D. An oxidation, or the loss of an electron, and a reduction, or the gain of an electron.

Blooms Level: 4. Analyze
Gradable: automatic
LO: 02.02.01 Compare and contrast the types of atomic interactions that lead to the formation of molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules

45. Five unknown compounds are added to water. Four of the compounds go into solution while one does not. What property does water possess that allows these four compounds to dissolve? Why might the fifth compound not dissolve?
A. The positive and negative charge in water will dissolve many substances; the substance is not structurally similar to water.
B. The negative charge of water dissolves many substances; the substance is too structurally similar to water.
C. The positive charge of water dissolves many substances; the substance is too structurally similar to water.
D. The nonpolar qualities of water dissolves many substances; the substance is not structurally similar to water.

Blooms Level: 3. Apply
Gradable: automatic
LO: 02.04.01 Describe how hydrogen bonding determines many properties of water.
Section: 02.04 Properties of Water

46. 1 mole = 1000 millimoles (mmol); 1millimole = 1000 micromoles (µmol). If a solution contains 38231 µmol, what is that amount in mmol?
A. 382.31 mmol
B. 38.231 mmol
C. 3.8231 mmol
D. 3823.1 mmol

Blooms Level: 3. Apply
Gradable: automatic
LO: 02.01.04 Quantify atomic mass using units such as daltons and moles.
Section: 02.01 Atoms
Topic: Atoms
Type: Quantitative Reasoning

47. If 1000 millimoles make up a mole, how many grams of magnesium (Mg), which has an atomic mass of 24.305, will make a solution of 150 µmol?
A. 3.6mg
B. 2.4mg
C. 0.24mg
D. 36mg

Blooms Level: 3. Apply
Gradable: automatic
LO: 02.04.03 Explain how the molarity of a solution—the number of moles of a solute per liter of solution—is used to measure the concentration of solutes in solution.
Section: 02.04 Properties of Water
Type: Quantitative Reasoning

48. Using the periodic table as a tool, identify the atomic characteristic that would most quickly and efficiently identify any single element.
A. number of shells
B. number of neutrons
C. number of protons and electrons
D. number of neutrons and electrons

Blooms Level: 5. Evaluate
Gradable: automatic
LO: 02.01.03 Relate atomic structure to the periodic table of the elements.
Section: 02.01 Atoms
Topic: Atoms

49. In the periodic table, the value that refers to the number of protons and neutrons is
A. atomic mass.
B. molecular molarity.
C. atomic molarity.
D. molecular number.

Blooms Level: 2. Understand
Gradable: automatic
LO: 02.01.03 Relate atomic structure to the periodic table of the elements.
Section: 02.01 Atoms
Topic: Atoms

50. You've been given three new elements. One element had all its protons removed, one element had all its neutrons removed, and one element had all its electrons removed. The removal that would have the largest effect on atomic mass would be
A. removing the protons.
B. removing the neutrons.
C. removing the electrons.
D. all the changes would affect the atomic mass.

Blooms Level: 3. Apply
Gradable: automatic
LO: 02.01.03 Relate atomic structure to the periodic table of the elements.
Section: 02.01 Atoms
Topic: Atoms

51. You have been asked to synthesize a new isotope for cadmium. Which part of the original atom would you need to manipulate in order to create an isotope?
A. Neutrons
B. Protons
C. Protons and neutrons
D. Electrons

Blooms Level: 3. Apply
LO: 02.01.05 Explain how a single element may exist in more than one form, called isotopes.
Section: 02.01 Atoms
Topic: Atoms

52. The single atom you would choose to remove from living organisms in order to remove the highest percentage of atoms would be
A. oxygen.
B. nitrogen.
C. hydrogen.
D. carbon.

Blooms Level: 3. Apply
Gradable: automatic
LO: 02.01.06 List the elements that make up most of the mass of all living organisms.
Section: 02.01 Atoms
Topic: Atoms

53. Water has fewer hydrogen atoms than lemon juice and a pH of around 7. Predict what will happen to the pH level of water when lemon juice is added.
A. The pH will become higher.
B. The pH will become lower.
C. The pH will remain the same.
D. There is not enough information to decide.

Blooms Level: 3. Apply
LO: 02.05.01 Explain how water has the ability to ionize into hydroxide ions (OH-) and into hydrogen ions (H), and how the H concentration is expressed as a solution's pH.
Section: 02.01 Atoms
Topic: Atoms

54. What is most accurate when comparing solutions with a pH of 6 and a pH of 8?
A. The solution with a pH of 8 has a 100 times higher concentration of hydrogen ions than a solution with a pH of 6.
B. Solutions with a pH of 8 has a 2 times lower concentration of hydrogen ions than a solution with a pH of 6.
C. The solution with a pH of 6 has a 100 times higher concentration of hydrogen ions than a solution with a pH of 8.
D. The solution with a pH of 6 has a 100 times lower concentration of hydrogen ions than a solution with a pH of 8.
E. The solution with a pH of 6 has a 2 times higher concentration of hydrogen ions than a solution with a pH of 8.

Blooms Level: 5. Evaluate
Gradable: automatic
LO: 02.05.01 Explain how water has the ability to ionize into hydroxide ions (OH-) and into hydrogen ions (H), and how the H concentration is expressed as a solution's pH.
Section: 02.05 pH and Buffers
Topic: pH and Buffers

55. During photosynthesis the reactants, carbon dioxide and water can become glucose and oxygen. Glucose and oxygen can also be reactants to form water and carbon dioxide. If the two reactions are working at a constant rate this would form a
A. homeostasis.
B. constant polarity.
C. universal balance.
D. chemical equilibrium.

Blooms Level: 2. Understand
Gradable: automatic
LO: 02.03.01 Relate the concept of a chemical reaction to the concept of chemical equilibrium.
Section: 02.03 Chemical Reactions
Topic: Chemical Reactions

56. What would be the most likely outcome if water molecules had a straight geometry instead of a bent geometry?
A. Hydrogen bonding between water molecules would have potentially shorter bond distance.
B. The partially positive ends would be at the poles of the molecule and the partially negative would be in the middle.
C. Water would tend to stack more closely and water would become more dense.
D. Water would take up more physical space.
E. Basic principles of chemistry and bonding would be violated.

Blooms Level: 5. Evaluate
Gradable: automatic
LO: 02.02.03 Describe how a molecule's shape is important for its ability to interact with other molecules.
Section: 02.02 Chemical Bonds and Molecules
Topic: Chemical Bonds and Molecules