# *Principles of Life 3rd edition Hillis Test Bank*

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Name:_____ Class:_____ Date:_____

## Chapter 2

1. Two atoms have the same mass but different atomic numbers. How can this be?
   a. They both have the same number of neutrons, but different numbers of protons.
   b. They both have the same number of protons, but different numbers of neutrons.
   c. They both have the same number of electrons, but different numbers of protons.
   d. The sums of their protons and neutrons are the same, although their numbers of protons differ.
   e. The sums of their protons and electrons are the same, although their numbers of neutrons differ.

*ANSWER:* d

2. Because atoms can have the same number of protons but a different number of neutrons, elements have
   a. isotopes.
   b. an integer atomic mass value.
   c. more than one atomic number.
   d. various means of forming chemical bonds.
   e. isomers.

*ANSWER:* a

3. The element magnesium (Mg) has an atomic number of 12. Therefore, it has _____ electron shells and _____ electrons in the outermost shell.
   a. 2; 6
   b. 2; 10
   c. 3; 2
   d. 3; 4
   e. 4; 6

*ANSWER:* c

4. Refer to the table.

| Atom | Number of protons | Number of neutrons | Number of valence electrons |
|---|---|---|---|
| X | 19 | 20 | 1 |
| Y | 20 | 20 | 2 |

Which statement applies to atoms X and Y?
   a. The atoms are isotopes of the same element.
   b. The atoms fall in the same group on the periodic table.
   c. The atoms have similar chemical reactivities.
   d. The atoms have their highest-energy electrons in *s* orbitals.
   e. The atoms have the same atomic mass.

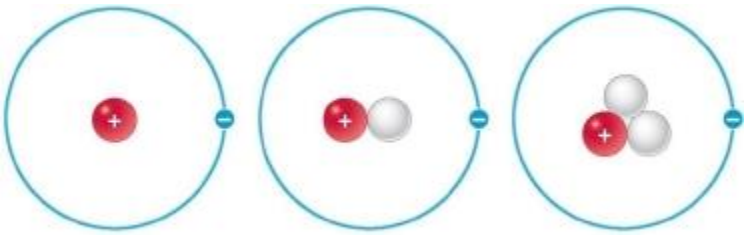
*ANSWER:* d

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5. Refer to the figure.



What is true about the three atoms shown in these Bohr models?

a. The atoms have different chemical reactivities.
b. The atoms have the same atomic mass.
c. The atoms represent three different elements.
d. The atoms are identical.
e. The atoms are isotopes of the same element.

*ANSWER:* e

6. Nitrogen-14 and nitrogen-15 are isotopes, and nitrogen-15 is used to determine protein structure. Based on this information, which statement is true?

a. Nitrogen-15 has more protons than nitrogen-14.
b. Nitrogen-15 has more neutrons than nitrogen-14.
c. Nitrogen-15 has more electrons than nitrogen-14.
d. Nitrogen-15 has the same number of protons and neutrons as nitrogen-14.
e. Nitrogen-15 has an electronic configuration that is different from that of nitrogen-14.

*ANSWER:* b

7. Carbon-12 is the most abundant isotope of carbon on Earth. Carbon-13 makes up about 1 percent of Earth's carbon atoms and is useful for radio imaging. Based on this information, which statement is true?

a. Carbon-13 has more protons than carbon-12.
b. Carbon-13 has more neutrons than carbon-12.
c. Carbon-13 has more electrons than carbon-12.
d. Carbon-13 has an electronic configuration that is different from that of carbon-12.
e. Carbon-13 has equal numbers of protons and neutrons.

*ANSWER:* b

8. Oxygen and carbon are defined as different elements because they have atoms with different numbers of

a. electrons.
b. protons.
c. neutrons.
d. nuclei.
e. atomic orbitals.

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*ANSWER:* b

9. There are _____ naturally occurring elements in the universe.
   a. 12
   b. 24
   c. 66
   d. 92
   e. 116

*ANSWER:* d

10. The atomic number of an element is the same as the number of _____ in each atom.
   a. neutrons
   b. protons plus electrons
   c. protons
   d. neutrons plus protons
   e. neutrons plus electrons

*ANSWER:* c

11. An atom with _____ has an atomic number of 14.
   a. 14 neutrons
   b. 14 electrons
   c. 14 protons
   d. 7 protons and 7 neutrons
   e. 6 electrons and 8 neutrons

*ANSWER:* c

12. Phosphorus has an atomic number of 15 and an atomic mass of 31. How many neutrons does it have?
   a. 5
   b. 16
   c. 30
   d. 31
   e. 47

*ANSWER:* b

13. Phosphorus-31 and phosphorus-32 have virtually identical chemical and biological properties because they have the same
   a. half-life.
   b. number of neutrons.
   c. atomic weight.
   d. mass number.
   e. number of electrons.

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*ANSWER:* e

14. The components of the atom that determine how the atom behaves chemically are the
    a. protons.
    b. outermost shell electrons.
    c. neutrons.
    d. innermost shell electrons.
    e. particles in the nucleus.

*ANSWER:* b

15. Which element has the same number of valence shell (outermost shell) electrons as oxygen?
    a. Calcium
    b. Nitrogen
    c. Fluorine
    d. Sodium
    e. Sulfur

*ANSWER:* e

16. Which element requires two additional electrons to fill the outermost electron shell?
    a. Phosphorus
    b. Carbon
    c. Nitrogen
    d. Oxygen
    e. Hydrogen

*ANSWER:* d

17. Carbon and silicon have the same number of
    a. protons.
    b. valence (outer shell) electrons.
    c. neutrons.
    d. electrons.
    e. protons and neutrons.

*ANSWER:* b

18. The ability of an atom to combine with other atoms is determined by the atom's
    a. atomic weight.
    b. ability to form isomers.
    c. number and distribution of electrons.
    d. nuclear configuration.
    e. protons and neutrons.

*ANSWER:* c

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19. An atom is most stable when
    a. it can have one unpaired valence electron, allowing it to follow the octet rule.
    b. it can share electrons with other atoms to form an uneven number of pairs of electrons.
    c. it has eight electrons.
    d. it can fill its outermost shell by sharing electrons or by gaining or losing one or more electrons until it is filled.
    e. its outermost electron shell follows the quartet rule.

*ANSWER:* d

20. Which element is the most chemically reactive?
    a. Carbon
    b. Helium
    c. Neon
    d. Argon
    e. Krypton

*ANSWER:* a

21. A covalent bond is the sharing of _____ between atoms, whereas an ionic bond is the _____.
    a. neutrons; sharing of electrons
    b. electrons; electrical attraction between two atoms
    c. protons; electrical attraction between two atoms
    d. protons; sharing of electrons
    e. electrons; transfer of electrons from one atom to another

*ANSWER:* e

22. Magnesium (Mg) has an atomic number of 12. When it bonds with another element, it will likely
    a. gain two electrons from the other element.
    b. share four electrons with the other element.
    c. lose two electrons to the other element.
    d. form a hydrogen bond.
    e. gain six electrons from the other element.

*ANSWER:* c

23. The two atoms in a hydrogen molecule are held together by
    a. hydrogen bonds.
    b. ionic attractions.
    c. van der Waals interactions.
    d. a shared pair of electrons.
    e. gravity.

*ANSWER:* d

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24. Which statement about the difference between ionic bonds and covalent bonds is true?
    a. An ionic bond is stronger than a covalent bond.
    b. A covalent bond occurs only in nonpolar molecules.
    c. An ionic bond occurs more often in aqueous solutions.
    d. An ionic bond occurs only in liquid methane.
    e. Electron sharing is more equal in the covalent bond.

*ANSWER:* e

25. Two carbon atoms held together in a double covalent bond share _____ electron(s).
    a. one
    b. two
    c. four
    d. six
    e. eight

*ANSWER:* c

26. Chlorine (Cl) has an atomic number of 17. When it bonds with another element, it will likely
    a. gain one electron from the other element.
    b. share four electrons with the other element.
    c. lose one electron to the other element.
    d. form a double bond.
    e. gain three electrons from the other element.

*ANSWER:* a

27. Refer to the table.

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| Element | Electronegativity |
|---|---|
| Fluorine (F) | 4.0 |
| Oxygen (O) | 3.4 |
| Chlorine (Cl) | 3.2 |
| Nitrogen (N) | 3.0 |
| Carbon (C) | 2.6 |
| Phosphorus (P) | 2.2 |
| Hydrogen (H) | 2.2 |
| Sodium (Na) | 0.9 |
| Potassium (K) | 0.8 |

Which pair of elements is *most* likely to react to form an ionic bond?

a. C and F
b. P and O
c. N and H
d. F and Na
e. Cl and C

*ANSWER:* d

28. A single covalent chemical bond represents the sharing of how many electrons?

a. One
b. Two
c. Three
d. Four
e. Six

*ANSWER:* b

29. Differences in the electronegativity of atoms that share electrons in a bond are involved in

a. a polar covalent bond.
b. an ionic bond.
c. a hydrogen bond.
d. van der Waals interactions.

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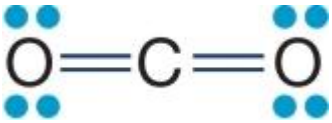
e. hydrophobic interactions.

*ANSWER:* a

30. The two covalent bonds in a water molecule are polar because
    a. oxygen is more electronegative than hydrogen.
    b. oxygen and hydrogen have similar electronegativities.
    c. oxygen is less electronegative than hydrogen.
    d. water is a small molecule.
    e. water is hydrophilic.

*ANSWER:* a

31. Refer to the figure showing the molecular structure of carbon dioxide.



Carbon dioxide is nonpolar, whereas water is polar. Which of the true statements below explains these differences?
    a. Carbon dioxide does not contain any polar covalent bonds, whereas water does.
    b. Carbon dioxide contains only double bonds, whereas water contains only single bonds.
    c. Carbon dioxide is a linear molecule, whereas water has a bent shape.
    d. Carbon dioxide contains carbon atoms, whereas water does not.
    e. Carbon and oxygen do not differ greatly in electronegativity, whereas hydrogen and oxygen do.

*ANSWER:* c

32. All these molecules are considered to be nonpolar *except* for
    a. $O_2$.
    b. $N_2$.
    c. $CH_4$.
    d. NaCl.
    e. $H_2$.

*ANSWER:* d

33. What determines if a molecule is polar, nonpolar, or ionic?
    a. The number of protons
    b. The bond distances
    c. The differences in the electronegativities of the atoms
    d. The ionic charges
    e. The distance of the electrons from the nucleus

*ANSWER:* c

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34. Which of the following is an example of a nonpolar covalent bond?
    a. P=O
    b. S—H
    c. C—O
    d. N=N
    e. F—Cl

*ANSWER:* d

35. Which statement about hydrogen bonds is true?
    a. They form between two hydrogen atoms.
    b. They form only between hydrogen and oxygen atoms within a molecule.
    c. They form between a highly electronegative atom and hydrogen.
    d. They involve a transfer of electrons.
    e. They are the strongest bonds because of their length.

*ANSWER:* c

36. The hydrogen bond between two water molecules forms because water is
    a. polar.
    b. nonpolar.
    c. a liquid.
    d. a small molecule.
    e. hydrophobic.

*ANSWER:* a

37. Hydrogen bonds
    a. form between two hydrogen atoms.
    b. form only between hydrogen and oxygen atoms within a molecule.
    c. form only between a weak electronegative atom and hydrogen.
    d. involve a transfer of electrons.
    e. form weak interactions but can provide structural stability when many are found in a single molecule.

*ANSWER:* e

38. Hydrogen bonds are attractions
    a. between oppositely charged ions.
    b. between atoms, resulting in electron sharing.
    c. between cations.
    d. between atoms, each with partial electrical charges.
    e. that rely on hydrophobic interactions.

*ANSWER:* d

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39. Which correctly shows the relative strengths of chemical bonds in *decreasing* order?
    a. Covalent bonds, hydrogen bonds, van der Waals interactions
    b. Hydrogen bonds, van der Waals interactions, covalent bonds
    c. van der Waals forces, covalent, hydrogen
    d. Hydrogen, covalent, van der Waals forces
    e. Covalent bonds, van der Waals interactions, hydrogen bonds

*ANSWER:* a

40. Geckos are able to climb smooth vertical walls easily because molecules on their feet form van der Waals interactions with molecules on the walls. Which statement explains this phenomenon?
    a. van der Waals interactions are weak noncovalent forces, but when there are many of these forces, they become significant.
    b. van der Waals interactions are weak noncovalent forces that are stronger than hydrogen bonds.
    c. van der Waals interactions are noncovalent forces but as strong as covalent bonds.
    d. van der Waals interactions are examples of strong dipole–dipole interactions.
    e. van der Waals interactions occur whenever there are huge differences in electronegativities between atoms.

*ANSWER:* a

41. A van der Waals interaction is an attraction between
    a. the electrons and the nucleus of one molecule.
    b. two nonpolar molecules, due to the exclusion of water.
    c. the electrons of one molecule and the protons of a nearby molecule.
    d. two adjacent nonpolar molecules, due to variations in their electron distribution.
    e. two polar molecules, because they are surrounded by water molecules.

*ANSWER:* d

42. Water held back by a dam represents what kind of energy?
    a. Hydroelectric
    b. Irrigation
    c. Potential
    d. Kinetic
    e. Metabolic

*ANSWER:* c

43. Which of the following represents kinetic energy?
    a. Chemical bonds
    b. Concentration gradient
    c. Electric charge imbalance
    d. Muscle contraction
    e. Separation of opposite charges

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*ANSWER:* d

44. The energy in a system that is due to state or position is called _____ energy.
    a. mechanical
    b. kinetic
    c. elastic
    d. potential
    e. chemical

*ANSWER:* d

45. Potential energy can be converted into _____ energy, which does work.
    a. chemical
    b. kinetic
    c. elastic
    d. gravitational
    e. nuclear

*ANSWER:* b

46. Which can *never* be created or destroyed?
    a. Entropy
    b. Energy
    c. Free energy only
    d. Thermal energy only
    e. Potential energy only

*ANSWER:* b

47. A conclusion of the first law of thermodynamics is that the total energy in the universe is
    a. decreasing.
    b. increasing.
    c. constant.
    d. being converted to free energy.
    e. being converted to matter.

*ANSWER:* c

48. During photosynthesis, plants use light energy to synthesize sugars from carbon dioxide. Plants do not make new energy; they merely convert it from light energy to chemical energy. This process is an illustration of
    a. entropy.
    b. chemical equilibrium.
    c. the first law of thermodynamics.
    d. the second law of thermodynamics.
    e. a spontaneous reaction.

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*ANSWER:* c

49. When a muscle contracts, muscle cells convert the chemical energy of glucose into kinetic energy and heat energy. In this case,
    a. the chemical energy is equal to the kinetic energy.
    b. the kinetic energy is equal to the heat energy.
    c. the chemical energy is equal to the sum of the kinetic and heat energies.
    d. the kinetic energy is equal to the sum of the chemical and heat energies.
    e. the heat energy is equal to the sum of the chemical and kinetic energies.

*ANSWER:* c

50. How does the second law of thermodynamics apply to organisms?
    a. As energy transformations occur, free energy increases and unusable energy decreases.
    b. To maintain order, life requires a constant input of energy.
    c. The potential energy of chemical bonds can be converted to kinetic energy.
    d. Reactions occur only with an input of energy.
    e. It does not apply to organisms; the complexity of organisms contradicts the second law.

*ANSWER:* b

51. In any system, some of the energy is unusable for work. The unusable energy is a measure of the disorder of the system and is referred to as
    a. free energy.
    b. entropy.
    c. enthalpy.
    d. thermodynamics.
    e. equilibrium.

*ANSWER:* b

52. Suppose that, in a closed system, there is an input of energy as 1 kilojoule of light. The light energy is converted to glucose, then ATP, and finally to mechanical energy. Which statement about the amount of mechanical energy available is true?
    a. There is 1 kilojoule of mechanical energy available to do work.
    b. The amount of usable energy decreases with each conversion, so less than 1 kilojoule of energy is available for mechanical work.
    c. All the reactions involved are anabolic, so there is 0.25 kilojoule of mechanical energy available.
    d. All the reactions involved are exergonic, so the number of kilojoules of mechanical energy produced is greater than 1 kilojoule.
    e. All the reactions involved are endergonic, so without constant input of energy, no mechanical energy is produced.

*ANSWER:* b

53. The second law of thermodynamics states that disorder in the universe

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a. is constantly increasing.
b. is constantly decreasing.
c. remains constant.
d. is not measurable.
e. does not exist.

*ANSWER:* a

54. When a drop of ink is added to a beaker of water, the ink molecules become randomly dispersed throughout the water. This is an example of an increase in

a. potential energy.
b. matter.
c. entropy.
d. complexity.
e. usable energy.

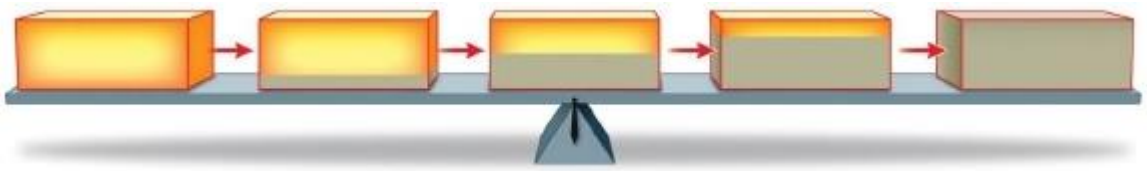
*ANSWER:* c

55. In a cell, molecules are broken down to serve as a source of chemical energy to build complex molecules from small molecules used as building blocks. As these transformations occur, the entropies of the complex molecules are _____, while the entropies of the molecules used as a source of chemical energy are _____.

a. constant; constant
b. increasing; constant
c. increasing; increasing
d. decreasing; decreasing
e. decreasing; increasing

*ANSWER:* e

56. Refer to the figure representing changes in energy during a series of chemical reactions within a cell.



What does the shaded portion, which gets larger in each consecutive box, represent?

a. Unusable thermal energy
b. Unusable chemical energy
c. Unusable light energy
d. Unusable kinetic energy
e. Unusable potential energy

*ANSWER:* a

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57. The $\Delta G$ of a reaction tells us all the following *except*

a. the rate of the reaction.
b. the direction of the reaction.
c. whether the reaction is exergonic or endergonic.
d. whether the reaction requires or releases energy.
e. whether a higher free energy is in the product or in the reactants.

*ANSWER:* a

58. Maltose ($C_{12}H_{22}O_{11}$) is composed of two molecules of glucose ($C_6H_{12}O_6$) bonded together. Which word equation correctly describes what happens when maltose undergoes hydrolysis?

a. Maltose → 2 glucose
b. Maltose → 2 glucose + $H_2O$
c. Maltose → 2 glucose + 2 $H_2O$
d. Maltose + $H_2O$ → 2 glucose
e. Maltose + 2 $H_2O$ → 2 glucose

*ANSWER:* d

59. How would the combined masses of the products of a chemical reaction compare with the combined masses of the reactants?

a. They would be equal.
b. Products would have greater mass than reactants in all reactions.
c. Reactants would have greater mass than products in all reactions.
d. In some reactions products would have greater mass, and in other reactions reactants would have greater mass.
e. The same reaction can produce products with greater mass under some conditions, and reactants with greater mass under other conditions.

*ANSWER:* a

60. Glucose ($C_6H_{12}O_6$) reacts with oxygen ($O_2$) to produce carbon dioxide ($CO_2$) and water ($H_2O$). How many molecules of carbon dioxide will be produced for each molecule of glucose that participates in this reaction?

a. 1
b. 2
c. 3
d. 6
e. 12

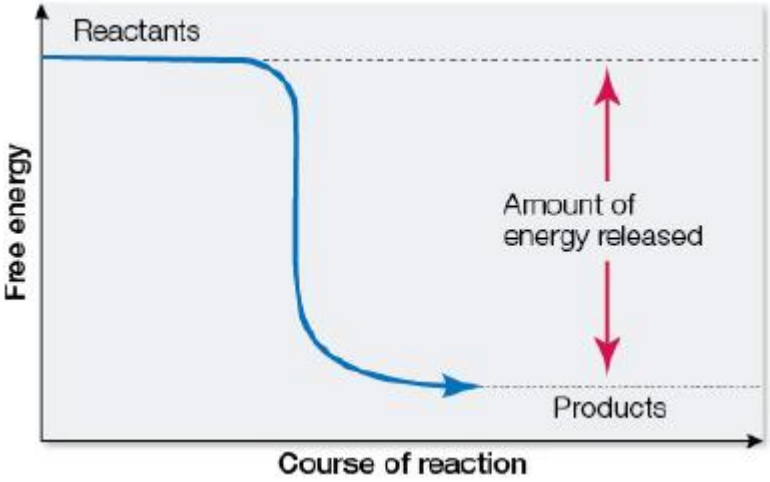
*ANSWER:* d

61. Refer to the figure showing the change in free energy resulting from a chemical reaction.

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Which statement about the reaction is true?

a. It is an endergonic reaction.
b. The reactants have less energy than the products.
c. $\Delta G$ is negative.
d. It is an example of a condensation reaction.
e. The reaction requires a net input of energy.

*ANSWER:* c

62. Knowing the change in free energy ($\Delta G$) of a reaction tells us the

a. energy yield of the reaction.
b. rate of the reaction.
c. end concentration of products.
d. optimum temperature for the reaction.
e. activation energy.

*ANSWER:* a

63. If $\Delta G$ of a chemical reaction is negative, that reaction will

a. release energy in the process.
b. require the input of energy.
c. not be spontaneous.
d. not proceed.
e. decrease the disorder in the system.

*ANSWER:* a

64. During an endergonic reaction,

a. more bonds are broken in the reactants than are formed in the products.
b. more bonds are formed in the products than are broken in the reactants.
c. more energy is released during bond formation than is absorbed during bond breaking.

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d. more energy is absorbed during bond breaking than is released during bond formation.
e. the amount of energy absorbed during bond breaking is the same as that released during bond formation.

*ANSWER:* d

65. _____ influences the rate of a reaction.
a. Entropy
b. $\Delta G$
c. The laws of thermodynamics
d. The activation energy
e. The overall change in free energy

*ANSWER:* d

66. The hydrolysis of sucrose to glucose and fructose is exergonic. However, if sucrose is dissolved in water and the solution is kept overnight at room temperature, there is no detectable conversion to glucose and fructose. Why?
a. The change in free energy of the reaction is positive.
b. The activation energy of the reaction is high.
c. The change in free energy of the reaction is negative.
d. This is a condensation reaction.
e. The free energy of the products is higher than the free energy of the reactants.

*ANSWER:* b

67. A chemist is running a chemical reaction in a flask in the lab, but the reaction is progressing very slowly. What can be done to speed up the reaction?
a. Transfer the reaction to a larger flask.
b. Put the reaction flask in the refrigerator.
c. Run the reaction in the dark.
d. Add more reactant molecules.
e. Add more solvent.

*ANSWER:* d

68. The rate of a chemical reaction is observed to increase. Which pair of factors could be responsible for causing this observed change?
a. Increasing activation energy and increasing reactant concentration
b. Decreasing reactant concentration and increasing temperature
c. Decreasing activation energy and decreasing temperature
d. Increasing reactant concentration and increasing temperature
e. Increasing temperature and increasing activation energy

*ANSWER:* d

69. Sweating is a useful cooling device for humans because water

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a. has a high heat of vaporization.
b. has little cohesion strength.
c. has little hydrogen bonding.
d. is an outstanding solvent.
e. ionizes readily.

*ANSWER:* a

70. Ice is used to cool beverages primarily because
a. it is composed only of water.
b. it floats.
c. it dilutes the taste.
d. people like to chew it.
e. it absorbs a lot of heat when it melts because of hydrogen bonding.

*ANSWER:* e

71. If you place a paper towel in a dish of water, the water will move up the towel by capillary action because water
a. molecules ionize.
b. is a good solvent.
c. molecules have hydrophobic interactions.
d. can form hydrogen bonds with the surface of the paper towel.
e. takes up large amounts of heat when it vaporizes.

*ANSWER:* d

72. When exposed to extreme heat, the human body relies on _____ to absorb excess heat and maintain normal body temperature.
a. evaporation
b. condensation
c. respiration
d. transpiration
e. convection

*ANSWER:* a

73. Ice floats because the ice crystals
a. contain fewer water molecules per volume than the liquid water.
b. are more dense than liquid water.
c. form heat, which makes water expand.
d. can move quickly and therefore can float.
e. have a high surface tension.

*ANSWER:* a

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74. A car sitting in the sun on a hot summer day becomes very hot to the touch. Water in a bucket sitting next to the car under the same conditions for the same length of time feels cool to the touch. Which statement explains this difference?

a. Radiant energy goes into breaking the forces of attraction between water molecules before increasing their rate of motion.
b. Radiant energy is reflected off the surface of water rather than being absorbed by the water molecules.
c. Radiant energy cannot easily penetrate water, because of its density, and is therefore not absorbed readily.
d. Radiant energy is absorbed poorly by liquids, compared with solids.
e. Radiant energy is absorbed by certain elements more readily than by other elements.

*ANSWER:* a

75. What features of the water molecule are responsible for its high heat of vaporization, and what other compound shares these features?

a. Water's small size and low molecular weight; carbon dioxide ($CO_2$)
b. Water's polarity and its ability to form intermolecular hydrogen bonds; ammonia ($NH_3$)
c. Water's single bonds and tetrahedral bond orientations; methane ($CH_4$)
d. Water's bent shape and lone pairs of electrons; sulfur dioxide ($SO_2$)
e. Water's covalent bonds involving hydrogen and oxygen atoms; hydrogen peroxide (HOOH)

*ANSWER:* b

76. Surface tension and cohesion occur in pure water because water

a. is nonpolar.
b. contains covalent bonds.
c. forms intermolecular hydrogen bonds.
d. resists changes in temperature.
e. requires high energy input to vaporize.

*ANSWER:* c

77. Vertebrate animals rely on movement of sodium ions in and out of nerve cells to transmit nerve impulses. Which property of water is relevant to this function, and why?

a. Water's strong adhesive properties, because this property explains the attraction between water and other substances
b. Water's changing density with temperature, because this property allows water to move as it heats up
c. Water's polarity, because this property makes it an effective solvent for charged particles
d. Water's high surface tension, because this property allows water to act as a surface that cannot be penetrated easily
e. Water's strong cohesive properties, because this property explains the attraction between water and itself

*ANSWER:* c

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78. Cholesterol is composed primarily of carbon and hydrogen atoms and is therefore
    a. insoluble in water.
    b. a polar molecule.
    c. a base.
    d. an acid.
    e. a buffer.

*ANSWER:* a

79. Molecules containing large numbers of hydroxyl groups are
    a. basic.
    b. structurally less stable than those with fewer hydroxyls.
    c. complex macromolecules.
    d. nonpolar.
    e. soluble in water.

*ANSWER:* e

80. Which of these compounds can be expected to have the *lowest* solubility in water?
    a. $C_6H_{12}$
    b. $NH_4^+$
    c. KCl
    d. $CH_3OH$
    e. $PO_4^{3-}$

*ANSWER:* a

81. Which of these compounds can be expected to have the highest solubility in water?
    a. $CH_3CH_2CH_2CH_2SH$
    b. HOOH
    c. $CH_3CH_2OH$
    d. $CH_4$
    e. $CH_3CH_2CH_2CH_2OH$

*ANSWER:* b

82. Which compound will break apart and have its parts surrounded by hydration shells when it is placed in water?
    a. $CH_3OH$
    b. $NH_3$
    c. $NO_2$

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d. $MgCl_2$

e. $CO_2$

*ANSWER:* d

83. When 0.1 mole of sodium hydroxide (NaOH) is added to 1 liter of water, it ionizes, releasing $OH^-$ and $Na^+$ ions. The resulting solution is

a. acidic.

b. basic.

c. neutral.

d. molar.

e. a buffer.

*ANSWER:* b

84. The difference between an acid and a base is that an acid _____, whereas a base _____.

a. undergoes a reversible reaction; does not

b. releases $OH^-$ ions in solution; accepts $OH^-$ ions

c. releases $H^+$ ions in solution; accepts $H^-$ ions

d. releases $OH^-$ ions in solution; releases $H^+$ ions

e. releases $H^+$ ions in solution; accepts $H^+$ ions

*ANSWER:* e

85. Which has the greatest concentration of hydrogen ions?

a. Household ammonia at pH 11

b. Baking soda at pH 9

c. Human blood at pH 7

d. Black coffee at pH 5

e. Cola at pH 3

*ANSWER:* e

86. Which statement comparing a solution of lemon juice (pH about 2) to a solution of tomato juice (pH about 4) is true?

a. The lemon juice has more hydroxyl ions per liter.

b. The lemon juice has more hydrogen acceptors per liter.

c. The lemon juice has more $H^+$ ions per liter.

d. The lemon juice has a higher pH.

e. The lemon juice has a more basic pH.

*ANSWER:* c

87. Carbonic acid and sodium bicarbonate act as a buffer in the blood. When a small amount of acid is added to

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this buffer, the $H^+$ ions are used up as they combine with the bicarbonate ions. When this happens, the pH of the blood

a. becomes basic.
b. becomes acidic.
c. changes very little.
d. is reversible.
e. ionizes.

*ANSWER:* c

88. The amino and carboxyl functional groups tend to form bases and acids. Each of these R groups does this by attracting or releasing

a. a neutron.
b. a proton.
c. an electron.
d. a proton and an electron.
e. a neutron and a proton.

*ANSWER:* b

89. Aldehydes and ketones are very similar in that they both contain

a. phosphorus atoms.
b. sulfur atoms.
c. C=O groups.
d. nitrogen atoms.
e. two R groups.

*ANSWER:* c

90. The functional group written as –COOH is called the _____ group.

a. sulfhydryl
b. hydroxyl
c. methyl
d. carboxyl
e. amino

*ANSWER:* d

91. Because of its six hydroxyl groups attached to its six-carbon backbone, the carbohydrate compound inositol can be classified as a(n)

a. alcohol.
b. aldehyde.
c. ketone.
d. carboxylic acid.
e. organic phosphate.

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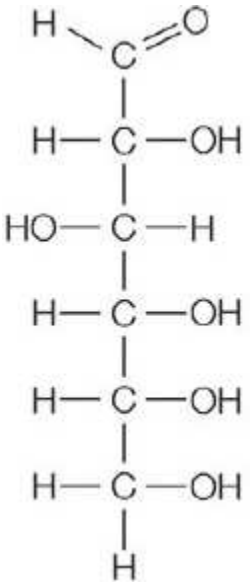
*ANSWER:* a

92. Which functional group would be *least* likely to occur on the surface of a large biological molecule, where it would interact with water molecules?

a. Carboxyl
b. Phosphate
c. Amino
d. Hydroxyl
e. Methyl

*ANSWER:* e

93. Refer to the figure showing the molecular structure of glucose.



Which functional groups are present?

a. Methyl and ketone
b. Aldehyde and carboxylic acid
c. Amino and hydroxyl
d. Carboxylic acid and methyl
e. Hydroxyl and aldehyde

*ANSWER:* e

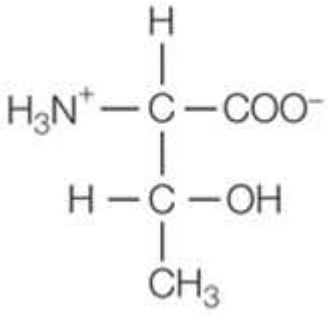
94. Refer to the figure showing the molecular structure of threonine.

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Which functional groups are present?

a. Amino, ketone, carboxyl, and sulfhydryl
b. Methyl, amino, carboxyl, and hydroxyl
c. Phosphate, aldehyde, amino, and methyl
d. Carboxyl, sulfhydryl, hydroxyl, and amino
e. Hydroxyl, methyl, carboxyl, and aldehyde

*ANSWER:* b

95. Refer to the table.

| | Amino acid 1 | Amino acid 2 |
|---|---|---|
| Chemical formula | $C_3H_7NO_3$ | $C_3H_7NO_3$ |
| Mass | 105.1 g/mole | 105.1 g/mole |
| Appearance | White crystals | White crystals |
| Solubility in water | Yes | Yes |
| Binding to a biological receptor | Yes | No |

Which statement about amino acids 1 and 2 is valid, given the data provided in the table?

a. They are identical in structure.
b. They have different R groups.
c. They are either structural isomers or stereoisomers.
d. They have opposite charges.
e. They contain different types of bonds.

*ANSWER:* c

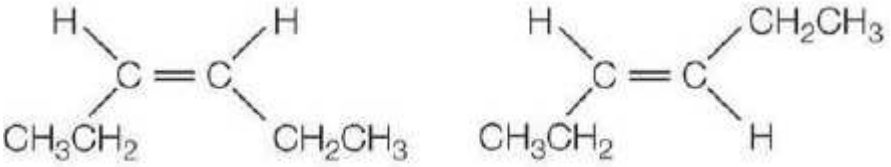
96. Refer to the figure.

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What could be true about this pair of compounds?

a. They have different chemical compositions.
b. They have different affinities for a biological receptor.
c. They have different molecular weights.
d. They have different chemical formulas.
e. They have different functional groups.

*ANSWER:* b

97. Refer to the table.

| Property | Compound X | Compound Y |
|---|---|---|
| Physical state at room temperature | Clear colorless liquid | Clear colorless liquid |
| Molecular weight | 86.2 g/mole | 86.2 g/mole |
| Chemical formula | $C_6H_{14}$ | $C_6H_{14}$ |
| Solubility in water | Insoluble | Insoluble |
| Boiling point | 57.9°C | 49.7°C |

What must be true about compounds X and Y?

a. They are identical.
b. They are mirror image stereoisomers.
c. They are structural isomers.
d. They are not identical and not isomers.
e. There is insufficient information to draw any conclusion about their structures.

*ANSWER:* c

98. Refer to the figure showing several structures of sugar molecules.

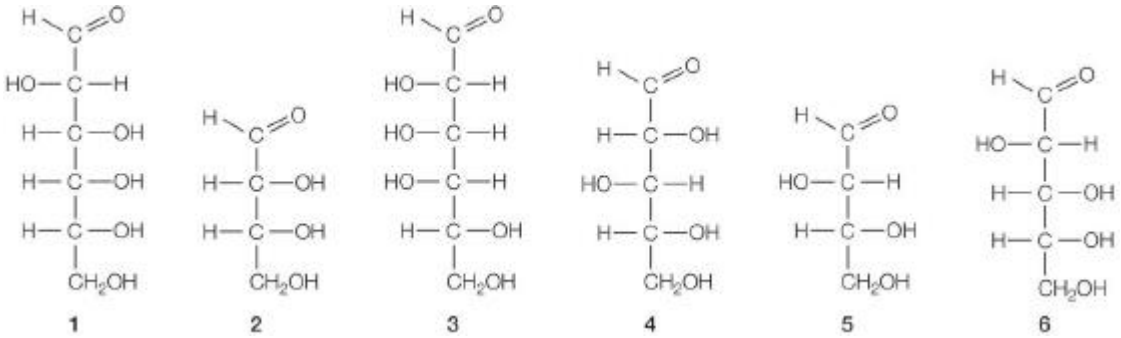
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Which two structures represent a pair of stereoisomers?

a. 1 and 4
b. 2 and 6
c. 4 and 5
d. 3 and 6
e. 2 and 5

*ANSWER:* e

99. Which property can be expected to be the same for any pair of structural isomers?

a. Molecular weight
b. Boiling point
c. Melting point
d. Density
e. Solubility in a given solvent

*ANSWER:* a

100. Which could be found to differ in a pair of structural isomers?

a. Number of atoms per molecule
b. Ratio of elements in each molecule
c. Biological activity of each molecule
d. Mass of a single molecule
e. Chemical formula

*ANSWER:* c

101. Refer to the figure showing part of the periodic table.

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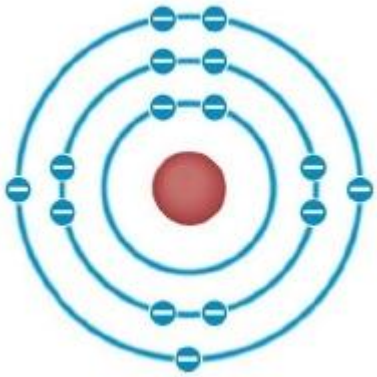
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**Chapter 2**

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 2<br>He<br>4.003 |
| 5<br>B<br>10.81 | 6<br>C<br>12.011 | 7<br>N<br>14.007 | 8<br>O<br>15.999 | 9<br>F<br>18.998 | 10<br>Ne<br>20.179 |
| 13<br>Al<br>26.982 | 14<br>Si<br>28.086 | 15<br>P<br>30.974 | 16<br>S<br>32.06 | 17<br>Cl<br>35.453 | 18<br>Ar<br>39.948 |

Draw a Bohr model to show the atomic structure of an atom representing the element having an atomic number of 15.

*ANSWER:* Suggested Answer:
Phosphorus, or P.



102. Refer to the figure showing part of the periodic table.

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 2<br>He<br>4.003 |
| 5<br>B<br>10.81 | 6<br>C<br>12.011 | 7<br>N<br>14.007 | 8<br>O<br>15.999 | 9<br>F<br>18.998 | 10<br>Ne<br>20.179 |
| 13<br>Al<br>26.982 | 14<br>Si<br>28.086 | 15<br>P<br>30.974 | 16<br>S<br>32.06 | 17<br>Cl<br>35.453 | 18<br>Ar<br>39.948 |

A given atom has nine protons, ten neutrons, and nine electrons. What else can you identify about this atom using information from the periodic table?

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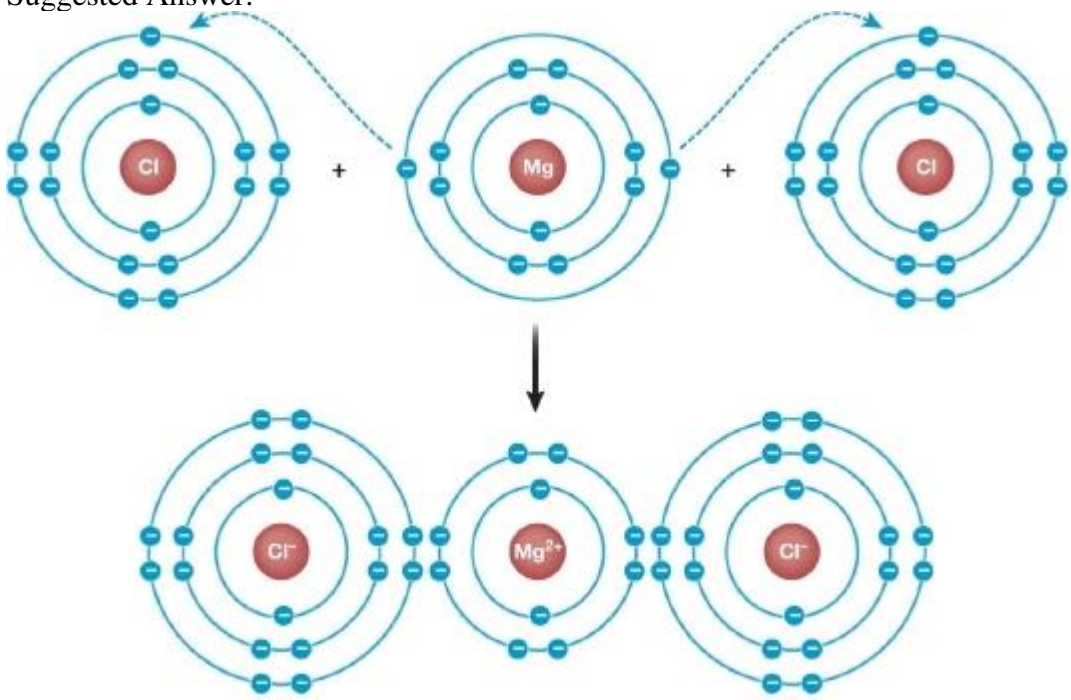
*ANSWER:* Suggested Answer:
The atom is a fluorine atom, has atomic number 9, and has an atomic weight of 18.998 Da.

103. Refer to the figure showing part of the periodic table.

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 2<br>He<br>4.003 |
| 5<br>B<br>10.81 | 6<br>C<br>12.011 | 7<br>N<br>14.007 | 8<br>O<br>15.999 | 9<br>F<br>18.998 | 10<br>Ne<br>20.179 |
| 13<br>Al<br>26.982 | 14<br>Si<br>28.086 | 15<br>P<br>30.974 | 16<br>S<br>32.06 | 17<br>Cl<br>35.453 | 18<br>Ar<br>39.948 |

Which element has the same number of electrons in its outer shell as silicon (Si), and how do you know?
*ANSWER:* Suggested Answer:
Carbon (C) has the same number of valence electrons as silicon. You can tell because they are both in the same column in the periodic table.

104. An ionic compound has the formula $XCl_2$, where X is a cation bonded through ionic attractions to two $Cl^-$ anions. Sketch Bohr models to show how the ions interact to form such a compound.
*ANSWER:* Suggested Answer:

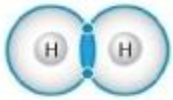
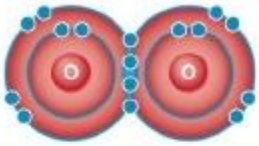
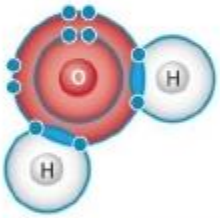
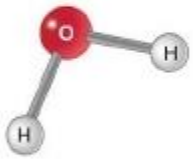
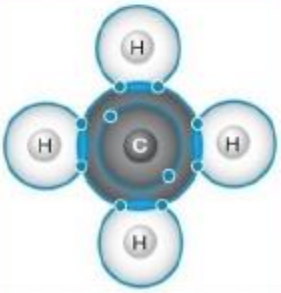
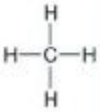
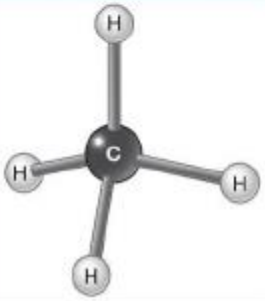



105. Refer to the figure.

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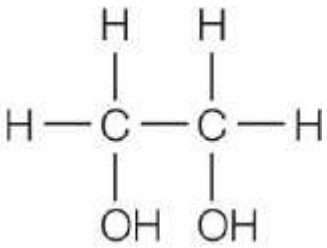
| Name (molecular formula) | Electron-shell diagram | Structural formula | Space-filling model | Ball-and-stick model |
|---|---|---|---|---|
| (A) Hydrogen ($H_2$) |  |  |  |  |
| (B) Oxygen ($O_2$) |  |  |  |  |
| (C) Water ($H_2O$) |  |  |  |  |
| (D) Methane ($CH_4$) |  |  |  |  |

Explain how these compounds represent examples of both polar and nonpolar molecules.

*ANSWER:* Suggested Answer:

$H_2$ and $O_2$ are nonpolar molecules because in each case, two atoms of equal electronegativity share the bonding electrons equally. In water, the oxygen is more electronegative than hydrogen and therefore pulls the bonding electrons to a greater extent, making the O–H bonds polar. Because the two O–H bonds are oriented at an angle, the two dipoles add together to make the entire water molecule polar. In methane, the C–H bonds are slightly polar because carbon has a slightly greater electronegativity than hydrogen. However, because the four C–H bonds are all oriented in a symmetrical fashion in a tetrahedral geometry, the four dipoles cancel one another, making the entire molecule nonpolar.

106. Refer to the figure.



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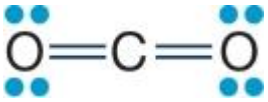
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How are the C–C bonds in this compound similar to and how are they different from the O–H bonds in this same compound?

*ANSWER:* Suggested Answer:
Both the C–C and O–H bonds are covalent bonds, which means that the bonding electrons are shared between the atoms. However, the bonding electrons are shared equally in the C–C bonds but unequally in the O–H bonds. The electronegativities are the same in the C–C bond, so no atom pulls the bonding electrons more closely than the other, which makes this bond nonpolar. The oxygen atom is more electronegative than the hydrogen atom and so pulls the bonding electrons closer, making the O–H bond polar.

107. Refer to the figure showing the molecular structure of carbon dioxide.



Carbon dioxide is nonpolar, whereas water is polar. What explains these differences?

*ANSWER:* Suggested Answer:
Each C=O bond is polar because oxygen is more electronegative than carbon, but the entire $CO_2$ molecule is nonpolar because the two bonds are oriented directly opposite from one another such that the dipoles cancel each other. In the water molecule, the two O–H bonds are polar as well, but they are oriented at an angle. Because they are at an angle, the dipoles do not cancel but create a net dipole for the molecule.

108. Refer to the table showing boiling point data for several organic compounds.

| Compound | Molecular formula | Boiling point (°C) |
|---|---|---|
| *n*-pentane | $CH_3CH_2CH_2CH_2CH_3$ | 36 |
| *n*-hexane | $CH_3CH_2CH_2CH_2CH_2CH_3$ | 68 |
| 1-pentanol | $CH_3CH_2CH_2CH_2CH_2OH$ | 138 |
| 1-hexanol | $CH_3CH_2CH_2CH_2CH_2CH_2OH$ | 157 |

How do noncovalent forces of attraction account for the large differences in boiling points of the alcohols versus the alkanes listed?

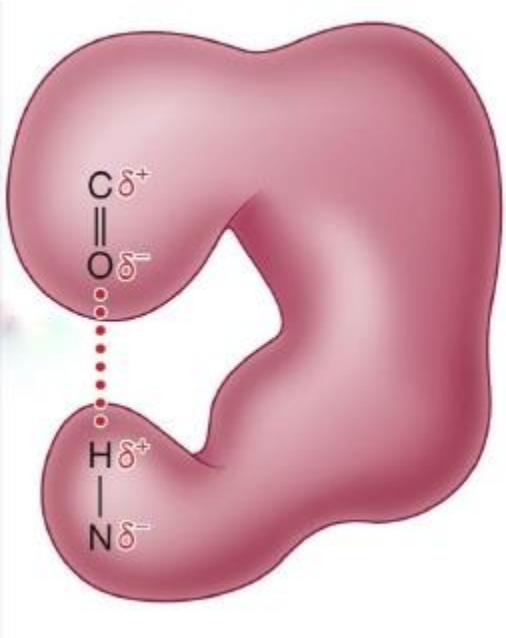
*ANSWER:* Suggested Answer:
The alcohols have higher boiling points than the alkanes because they have both van der Waals interactions and hydrogen bonds holding their molecules together. Hydrogen bonds form between hydroxyl groups present in alcohol molecules. Alkanes do not have any functional groups that can participate in hydrogen bonding, and so they have only van der Waals attractions between their molecules, and these are much weaker than hydrogen bonds.

109. Refer to the figure.

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What term is used for the type of interaction shown in the figure, and how does it affect large molecules like the one shown?

*ANSWER:* Suggested Answer:
The interaction shown is a hydrogen bond. This type of bond is a type of dipole–dipole interaction between portions of the same molecule and helps stabilize the 3-D structure of the molecule.

110. Energy has been defined as the capacity to produce a change. Use this definition to explain why all animals, including humans, need a constant input of food to stay alive.

*ANSWER:* Suggested Answer:
Animals need a constant input of energy in order to carry out the changes within their cells that are required for their survival. These include the cellular functions needed to grow, to repair damage, and to reproduce. Food is the source of chemical energy that animal cells can transform into the various forms of energy needed to perform their metabolic functions.

111. It is estimated that approximately 90 percent of energy that passes between levels in a food web is lost at each level. Explain the first law of thermodynamics, and discuss why this apparent loss of energy does not contradict that law.

*ANSWER:* Suggested Answer:
The first law of thermodynamics states that energy cannot be created or destroyed but that it may be converted from one form to another. The energy "lost" in the transfer between levels of a food web is converted from chemical energy to heat energy. There is a net loss of usable energy during each conversion, but the total amount of energy (usable plus unusable) remains the same.

112. Refer to the figures illustrating the first and second laws of thermodynamics

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## Chapter 2

Figure 1:

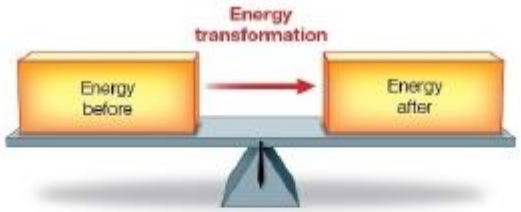



Figure 2:




Assign each figure to one of these laws, then explain the difference between the figures.

*ANSWER:* Suggested Answer:
Figure 1 illustrates the first law and figure 2 illustrates the second law of thermodynamics. Figure 1 is much simpler than figure 2 and shows only that the total amount of energy remains constant during energy transformations. Figure 2 contains elements of both laws: it shows that the total amount of energy remains constant but the amount of that energy that is usable by a biological system decreases at each energy transformation step.

113. Astronauts live on board the International Space Station for weeks and months at a time. The space station has an oxygen generator that uses the following chemical reaction for producing oxygen from water:

$2\ H_2O \rightarrow 2\ H_2 + O_2$

Explain how the numbers of hydrogen and oxygen atoms present before the reaction compare with the numbers of hydrogen and oxygen atoms present after the reaction. What does this comparison say about matter undergoing chemical change?

*ANSWER:* Suggested Answer:
There are equal numbers of hydrogen atoms before and after the reaction (four). Similarly, there are equal numbers of oxygen atoms before and after the reaction (two). This says that matter is not destroyed or created during chemical change, but only rearranged.

114. The hydrolysis of ATP (adenosine triphosphate) is an exergonic reaction that produces ADP (adenosine diphosphate) and inorganic phosphate as products. ADP can be further hydrolyzed in a second exergonic reaction to produce AMP (adenosine monophosphate) and inorganic phosphate as products. How do ATP, ADP, and AMP compare with one another in terms of potential energy, and why?

*ANSWER:* Suggested Answer:
ATP has the greatest chemical potential energy; its hydrolysis releases energy in an exergonic reaction and produces ADP, another molecule with potential energy. ADP has the next highest level of chemical potential energy; its hydrolysis to AMP releases energy in another exergonic reaction. In both cases, the energy released comes from the chemical energy stored in the P–O bond broken as the reaction takes place.

115. Refer to the table showing the data for a chemical reaction between two reactants, 1 and 2. In all trials,

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conditions were identical except for the differences noted in the table.

| Trial | Concentration of reactant 1 (mole/liter) | Concentration of reactant 2 (mole/liter) | Reaction rate (mole/s) |
|---|---|---|---|
| 1 | 0.1 | 0.1 | $0.5 \times 10^{-4}$ |
| 2 | 0.2 | 0.1 | $1.0 \times 10^{-4}$ |
| 3 | 0.3 | 0.1 | $1.5 \times 10^{-4}$ |
| 4 | 0.4 | 0.1 | $2.0 \times 10^{-4}$ |

Use the concept of molecular collisions to explain the observed trend in reaction rate.

*ANSWER:* Suggested Answer:
The increase in reactant 1 concentration results in greater numbers of collisions per unit time between reactant molecules. The greater number of collisions per unit time results in more product formation per unit time, which explains the observed increase in reaction rate.

116. Two reactions are exergonic. One has a large activation energy, and the other has a small activation energy. Which reaction will tend to occur at a faster rate and why?

*ANSWER:* Suggested Answer:
The reaction with the small activation energy will occur at a faster rate because a greater proportion of reactant molecules will have enough energy to collide and react to form product. The reaction with the large activation energy has a much higher energy barrier to overcome. Far fewer reactant molecules will have sufficient energy to collide to form product, so far fewer product molecules will form and the rate of reaction will be much slower.

117. How do the densities of ice and liquid water differ? Justify your answer with a sketch.

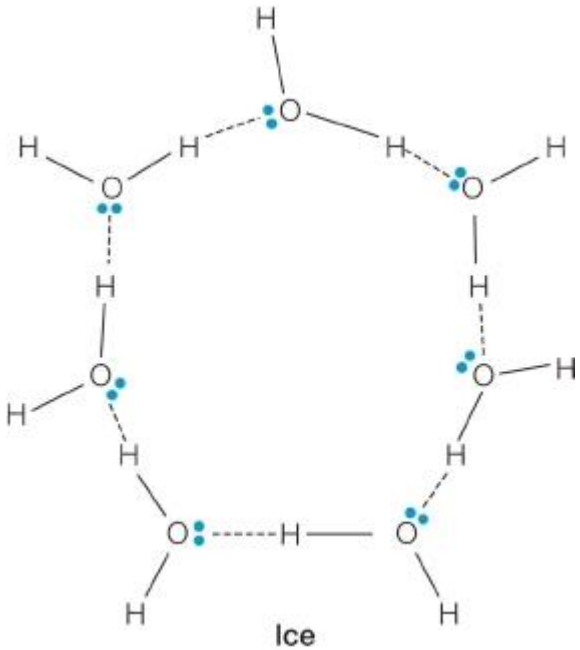
*ANSWER:* Suggested Answer:
(See sample sketches shown.) Ice is less dense than liquid water because of differences in packing of water molecules in the two phases, even though hydrogen bonding occurs in both states. The sketch below shows seven water molecules in each state. In ice, these molecules are more spread out since they occupy points in a lattice, while in the liquid state these molecules are packed more tightly since they do not form a regular lattice structure.

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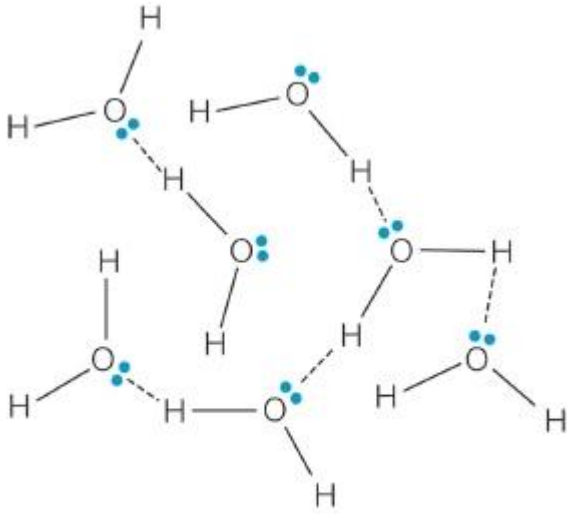


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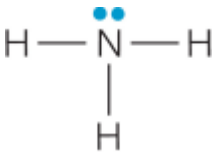


Ice



Liquid water

118. Refer to the figure showing the molecular structure of ammonia.



Would you expect liquid ammonia to have a specific heat similar to that of water or very different from that of water? Explain your reasoning.

*ANSWER:* Suggested Answer:
Liquid ammonia should have a specific heat similar to that of water. Both compounds are polar molecules, and both are capable of forming intermolecular hydrogen bonds in the liquid state.

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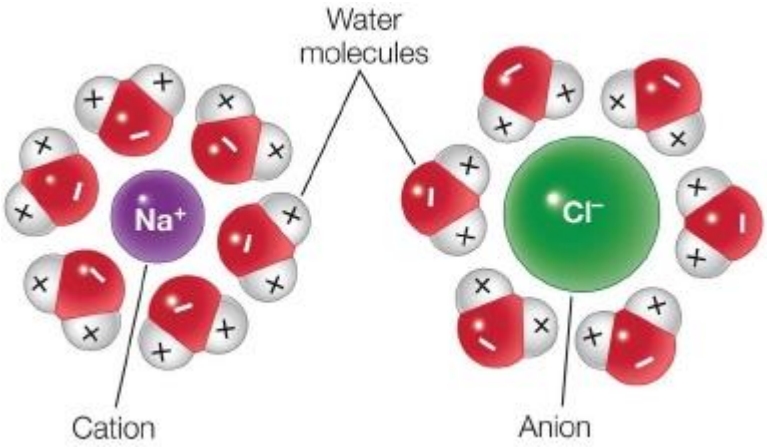

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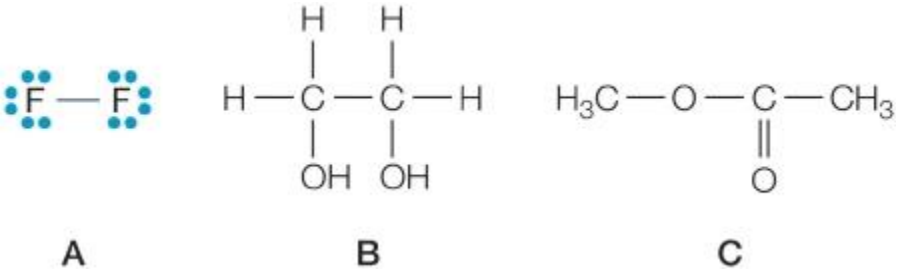
Because of these two properties, the molecules in both liquids are strongly attracted to one another. It takes a lot of energy to disrupt these attractive forces. This will be observed as high specific heats for both compounds.

119. Create a sketch to show what happens when sodium chloride dissolves in water. How does water interact with this compound to enable it to dissolve?

*ANSWER:* Suggested Answer:
(See sample sketch shown.) The sodium chloride dissociates into its component ions as it dissolves in water. Each ion becomes surrounded with a hydration shell—a layer of water molecules that orient themselves in a specific way based on the ion's electrical charge. For negatively charged ions, the water molecules orient themselves with the positive end of their dipoles closest to the ion and the negative end farthest away from the ion. For positively charged ions, the water molecules orient themselves with the negative ends of their dipoles closest to the positively charged ion.




120. Refer to the figure showing the molecular structures of three different compounds.




Predict whether each compound will be soluble or insoluble in water, and justify your predictions.

*ANSWER:* Suggested Answer:
Compound A will not be soluble in water because it is nonpolar and can only participate in van der Waals interactions with other molecules. Compound B will be soluble in water for two reasons: it is polar so it can participate in dipole–dipole interactions with water molecules, and it can participate in hydrogen bonding with water molecules. Compound C will be soluble in water because it is polar and so can participate in dipole–dipole interactions with water molecules.

121. Increasing carbon dioxide levels in the atmosphere has led to increasing acidity of the world's oceans. Explain this effect and include a chemical equation as part of your explanation.

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*ANSWER:* Suggested Answer:

Carbon dioxide reacts with water to produce $H_2CO_3$, which is an acid. Because it is an acid, $H_2CO_3$ is able to donate hydrogen ions to water, producing an excess of hydronium ions, which lowers the pH:

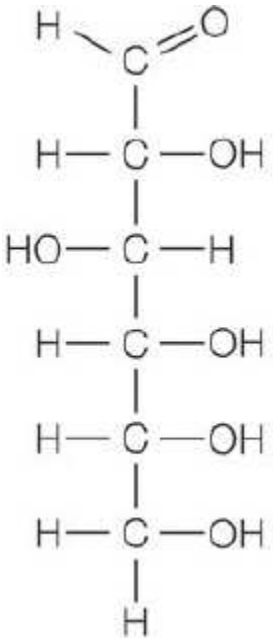
$$CO_2 + 2\ H_2O \rightarrow H_2CO_3 + H_2O \rightarrow HCO_3^- + H_3O^+$$

122. A buffer can absorb small additions of acid or base, but if there is a large influx of either acid or base, the buffer ceases to be functional. Why?

*ANSWER:* Suggested Answer:

A buffer consists of the combination of both the acid form and the base form of a compound dissolved in solution. If a small amount of acid is added to the buffer, this acid reacts with the base form of the buffer. This removes some of the base form of the buffer and leaves less available for reaction with more added acid. If too much acid is added, there will be no more base form of the buffer to react with it to remove it from solution.

123. Refer to the figure showing the structure of glucose, a six-carbon compound.



The structure of *n*-hexane also consists of six carbon atoms bonded in a linear chain. However, *n*-hexane contains no oxygen atoms, and the carbon chain is bonded only to hydrogen in the form of C–H bonds. Compare some properties of glucose and *n*-hexane that result from these differences in functional groups.

*ANSWER:* Suggested Answer:

Glucose is polar as a result of the many hydroxyl groups and the single aldehyde group present in its structure. In contrast, *n*-hexane is nonpolar because it has no polar functional groups. Glucose would therefore be very soluble in water, whereas *n*-hexane would not be soluble in water.

124. Compare and contrast the keto and carboxyl functional groups that are found in biological molecules. How are they similar and how do they differ?

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*ANSWER:* Suggested Answer:
A keto group and a carboxyl group each contain a carbon atom double-bonded to an oxygen atom (C=O), allowing them both to be polar in nature and to participate in hydrogen bonding interactions.
The carboxyl group also has a hydroxyl group, which easily loses its hydrogen atom as $H^+$. Thus, the carboxyl group can take on an ionic form with a negative charge and is acidic, while the keto group has no ionized form and is neither acidic nor basic.

125. Consider compounds with the general formula $C_nH_{2n+2}$. Starting with $n = 1$ and moving up in value sequentially, think about the possible molecular structures that can be drawn for each formula. What is the lowest $n$ value that corresponds to a formula that can exist as two or more structural isomers? How many structural isomers are possible for this formula?

*ANSWER:* Suggested Answer:
The lowest value of $n$ that gives a formula that can be represented by structural isomers is 4. $C_4H_{10}$ allows for both linear chain and branched chain structures. One linear and one branched chain structure can be drawn for a total of two structural isomers for this formula.

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