Use each of the terms just once to complete the following paragraphs.

<table>
<thead>
<tr>
<th>alloy</th>
<th>homogeneous</th>
<th>properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>aqueous</td>
<td>mass</td>
<td>qualitative</td>
</tr>
<tr>
<td>solution</td>
<td>matter</td>
<td>quantitative</td>
</tr>
<tr>
<td>chemistry</td>
<td>mixture</td>
<td>substances</td>
</tr>
<tr>
<td>heterogeneous</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The science that deals with the study of the “stuff” that makes up the universe is (1) _______________, although a better name for “stuff” is (2) _______________. The measure of the amount of “stuff” in an object is the (3) _______________ of the object. A description of a material using measurements is called a(n) (4) _______________ observation, compared to a(n) (5) _______________ observation, such as color or odor. The kinds of observations you can make about an object, such as its size, shape, color, odor, and tendency to react with other substances, are called the (6) _______________ of the object.

Materials can be classified as (7) _______________ if they have the same composition throughout, or (8) _______________ if their composition varies from region to region. Examples of the former are elements and compounds, both of which are classified as (9) _______________ because of their fixed compositions. An example of the latter is a combination of sand and salt that can be separated rather easily. This combination is called a(n) (10) _______________. All homogeneous mixtures are (11) _______________. A solution of two or more metals such as brass is a(n) (12) _______________.

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For each item in Column A, write the letter of the best matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. __________ 3000 grams</td>
<td>a. scientific model</td>
</tr>
<tr>
<td>14. __________ property</td>
<td>b. name of an element</td>
</tr>
<tr>
<td>15. __________ drawing of a molecule</td>
<td>c. chemical symbol of an element</td>
</tr>
<tr>
<td>16. __________ 3.48 meters</td>
<td>d. aqueous solution</td>
</tr>
<tr>
<td>17. __________ green</td>
<td>e. physical change</td>
</tr>
<tr>
<td>18. __________ oxygen</td>
<td>f. chemical formula</td>
</tr>
<tr>
<td>19. __________ carbon dioxide</td>
<td>g. color, odor, weight, size, shape, hardness</td>
</tr>
<tr>
<td>20. __________ sugar water</td>
<td>h. name of a compound</td>
</tr>
<tr>
<td>21. __________ brass</td>
<td>i. qualitative observation</td>
</tr>
<tr>
<td>22. __________ boiling</td>
<td>j. mass measurement</td>
</tr>
<tr>
<td>23. __________ Sn</td>
<td>k. alloy</td>
</tr>
<tr>
<td>24. __________ CaCO₃</td>
<td>l. quantitative observation of length</td>
</tr>
</tbody>
</table>

Answer the following questions.

25. How do the submicroscopic and macroscopic views of matter differ?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

26. How are the submicroscopic and macroscopic views related?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

27. Suppose you make lemonade by dissolving a dry mix in water.
   a. What is the solute? ________________________________
   b. What is the solvent? ________________________________
   c. What is the aqueous solution? _______________________

28. The chemical formula for water is H₂O. What does this formula tell you about water?

______________________________________________________________________________

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In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

1. The freezing point of water is an example of a _________.
   a. chemical change  c. physical state
   b. chemical property  d. physical property

2. The temperature most commonly taken as room temperature in scientific discussions is about _________.
   a. 0°C  c. 20°C
   b. 100°C  d. 37°C

3. The name given to the change of state from gas to liquid is _________.
   a. condensation  c. freezing
   b. evaporation  d. cooling

4. If a substance has an odor, it is _________.
   a. a solid  c. volatile
   b. a liquid  d. a pure substance

5. The density of an object with a volume of 3.0 mL and a mass of 15.0 g is _________.
   a. 45.0 g/mL  c. 0.2 g/mL
   b. 5.0 g/mL  d. 12.0 g/mL

6. The material with the lowest density among those listed is _________.
   a. gold  c. hydrogen gas
   b. water  d. gasoline

7. An example of a chemical change is _________.
   a. the boiling of water  c. the rusting of iron
   b. the evaporation of alcohol  d. the breaking of glass

8. Suppose six atoms of oxygen are present at the beginning of a chemical reaction. How many oxygen atoms are present when the reaction is over?
   a. always six  c. more than six
   b. fewer than six  d. no way of telling

9. Materials like pewter are classified as a(n) _________.
   a. aqueous solutions  c. alloys
   b. heterogeneous solutions  d. compounds
For items 10–17, classify each of the following as a chemical or physical change.

10. wind eroding rocks ________________
11. dead leaves decaying ________________
12. rain puddle drying up ________________
13. mixing flour and baking powder ________________
14. gasoline evaporating ________________
15. hydrogen peroxide decomposing ________________
16. bread baking in an oven ________________
17. instant tea dissolving in water ________________

18. A 15 mL sample of a solid is weighed. The mass is recorded as 29 g. What is the density of the solid? ________________

Identify each of the following changes as endothermic or exothermic.

19. decomposition of water ________________
20. burning wood ________________
21. photosynthesis ________________
22. explosion of fireworks ________________
2.1 Atoms and Their Structure

Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

1. The ancient Greeks believed that matter is made of four basic elements: earth, air, fire, and oxygen. **T**

2. The man who proposed the first modern atomic theory of matter was Antoine Lavoisier. **T**

3. The law of definite proportions says that the composition of a compound is always the same. **T**

4. In science, a prediction that can be tested is known as a theory. **T**

5. The tiny negatively charged particles discovered by J.J. Thomson in 1897 were electrons. **T**

6. The number of protons in an atom is always equal to the number of neutrons. **T**

7. Isotopes differ from one another in their chemical properties. **T**

8. Rutherford’s gold foil experiment led to the discovery of the portion of the atom known as the nucleus. **T**

9. The largest portion of an atom is taken up by the nucleus. **T**

10. The mass number of an atom is equal to the total number of protons and neutrons. **T**

11. Scientists use the symbol _g_ to represent the atomic mass unit. **T**

12. An atomic mass unit is about equal to the mass of one proton. **T**

Supply the missing information needed to complete the table below.

<table>
<thead>
<tr>
<th>Element</th>
<th>Atomic number</th>
<th>Mass number</th>
<th>Number of protons</th>
<th>Number of neutrons</th>
<th>Number of electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. sodium</td>
<td>11</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. hydrogen</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. neon</td>
<td></td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. fluorine</td>
<td></td>
<td>10</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. uranium</td>
<td></td>
<td>92</td>
<td>146</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. aluminum</td>
<td></td>
<td>14</td>
<td>13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Answer the following questions.

19. Which two of the three statements that make up Dalton’s atomic theory are no longer regarded as true as stated by Dalton? ________________________________

20. Is it correct or incorrect in science to define a theory as someone’s best guess about an aspect of nature? Explain your answer. ________________________________

21. What evidence convinced J.J. Thomson that an atom consists of more than electrons? ________________________________

22. What feature of Rutherford’s gold foil experiment was most surprising to those who carried out the experiment? ________________________________

23. Could two isotopes of an element have different numbers of protons? Explain. ________________________________

24. The element boron has two isotopes, with mass numbers of 10 and 11. The abundance of the two isotopes is 20 percent and 80 percent, respectively. Without making a mathematical calculation, estimate the atomic mass of boron. ________________________________
2.2 Electrons in Atoms

For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. electron</td>
<td>a. positively charged center of an atom</td>
</tr>
<tr>
<td>2. empty space</td>
<td>b. electromagnetic energy with the highest frequency</td>
</tr>
<tr>
<td>3. atomic nucleus</td>
<td>c. represents valence electrons</td>
</tr>
<tr>
<td>4. Niels Bohr</td>
<td>d. negative particle found in an atom</td>
</tr>
<tr>
<td>5. Lewis dot diagram</td>
<td>e. region around a nucleus where an electron can be found</td>
</tr>
<tr>
<td>6. hertz</td>
<td>f. high-frequency wave</td>
</tr>
<tr>
<td>7. gamma rays</td>
<td>g. most of an atom</td>
</tr>
<tr>
<td>8. radio waves</td>
<td>h. light released from excited atoms</td>
</tr>
<tr>
<td>9. emission spectrum</td>
<td>i. found in the outermost energy level</td>
</tr>
<tr>
<td>10. energy level</td>
<td>j. suggested that electrons orbit the atom’s nucleus</td>
</tr>
<tr>
<td>11. short wavelength</td>
<td>k. unit of frequency of a wave</td>
</tr>
<tr>
<td>12. valence electrons</td>
<td>l. electromagnetic radiation with the lowest energy</td>
</tr>
</tbody>
</table>

The diagram below shows a cross-sectional view of an atom. Answer the following two questions about this diagram.

![Atom Diagram]
13. What letter or letters on the diagram represents each of the following features of the atom?
   a. the nucleus: ____________
   b. energy levels: ____________
   c. the valence electrons: ____________
   d. electron cloud: ____________

14. An emission spectrum containing 3 lines is obtained from an excited atom as shown in the diagram. For each line in Column A, write the letters of the matching transition shown in the diagram in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. line x, 400 nm</td>
<td>a. C to B</td>
</tr>
<tr>
<td>2. line y, 650 nm</td>
<td>b. D to C</td>
</tr>
<tr>
<td>3. line z, 750 nm</td>
<td>c. D to B</td>
</tr>
</tbody>
</table>

15. Write a Lewis dot diagram for each of the following elements.
   a. Na (11 electrons)
   b. C (6 electrons)
   c. Al (13 electrons)
   d. Cl (17 electrons)
   e. Ne (10 electrons)
   f. Sr (38 electrons)

16. Which form of electromagnetic radiation would you associate with each of the following descriptions?
   a. waves with energy just less than that of visible light ________________
   b. the form of electromagnetic energy with the shortest wavelength ________________
   c. electromagnetic energy with the longest wavelengths ________________
   d. electromagnetic energy with a frequency just less than that of gamma rays ________________

17. Because electrons are traveling so fast, why do they not fly away from the atom?
   ________________

18. Chemistry teachers used to compare the structure of an atom to the structure of our solar system. In what way is that model correct? In what way is it not correct?
   ________________
   ________________

19. Why do you suppose that an energy level close to the nucleus can hold fewer electrons than one farther away from the nucleus?
   ________________
Use each of the terms below just once to complete the following passage.

triads  halogen  rows
döbereiner  atomic numbers  mendeleev
atomic mass  periodicity  eka-aluminum
noble gases

One of the earliest efforts to group the chemical elements in some kind of logical sequence was made by the German chemist (1) _________________ in 1829. This effort was based on the fact that some elements have similar properties and can be placed in groups of three elements, called (2) _________________. An example of such a group is the (3) ________________ group, consisting of chlorine, bromine, and iodine. A more sophisticated method for grouping the elements was suggested in 1869 by the Russian chemist (4) _________________. This method was based on the fact that, when the elements are arranged in order according to their (5) _________________, their properties appear to repeat on a regular basis, a phenomenon known as (6) _________________. In the first periodic table, elements with similar properties were placed together in (7) _________________. Proof that this system of arranging the elements was correct came with the successful prediction of an element that had not yet been discovered, an element given the name of (8) _________________. That element was actually discovered less than 20 years later. The primary way in which the modern periodic table differs from the original periodic table is that elements are now arranged according to their (9) _________________. The rows in the modern periodic table begin with metals and end with (10) _________________.

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Circle the letter of the choice that is the best response or that best completes the statement.

11. In 1860, chemists could make which of the following statements about the known chemical elements?
   a. They all had identical properties.   b. Some had similar properties.
   c. They all had different properties.   d. They could not be grouped.

12. Early scientists classified _________ as one of the coinage metals.
   a. lithium   b. chlorine
   c. copper   d. iron

13. If the first and last elements in a triad have atomic masses of 7 and 39, respectively, then the atomic mass of the middle element is about _________.
   a. 23   b. 46
   c. 15.3   d. 32

14. Mendeleev's first periodic table consisted of _________ groups.
   a. 3   b. 18
   c. 8   d. 2

15. Which of the following is not a periodic phenomenon?
   a. rising of the sun   b. appearance of Halley's comet
   c. ocean tides   d. growth of a sunflower

16. When moving from left to right across the modern periodic table, the atomic numbers of the elements _________.
   a. do not change   b. increase by one
   c. decrease by one   d. are the same as the atomic masses

17. The modern periodic table is made up of _________ elements.
   a. 60   b. 111
   c. 92   d. 25

18. In Döbereiner's halogen triad, the density, boiling point, and melting point of the elements ________ as atomic mass increases.
   a. stay the same   b. increase
   c. double   d. decrease

19. In the modern periodic table, elements in the same ________ have similar properties.
   a. column   b. period
   c. row   d. area

20. Döbereiner and Mendeleev both tried to relate the properties of elements to their ________.
   a. number of electrons   b. atomic number
   c. number of protons   d. atomic mass
Select the group of elements that most closely fits each of the properties listed below. Write M for metals, N for nonmetals, and O for metalloids.

1. luster
2. tightly held valence electrons
3. at the right side of the periodic table
4. semiconductors
5. good conductors of electricity
6. usually quite brittle
7. properties intermediate between metals and nonmetals
8. a variety of colors
9. three to eight valence electrons
10. poor conductors of heat

Use the outline of the periodic table to complete the steps below. Each box represents an element.

11. Draw a straight blue line from the beginning to the end of any one period.
12. Draw a straight red line from the beginning to the end of any one group.
13. Place a V in any five boxes that you would expect to be metallic elements.
14. Place a W in any three boxes that you would expect to be nonmetallic elements.
15. Place an X in any box that you would expect to be a metalloid.
16. Place a Y in any box that you would expect to be a lanthanide element.
17. Place a Z in any box that you would expect to be an actinide element.
For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>18. hydrogen</td>
<td>a. has six valence electrons</td>
</tr>
<tr>
<td>19. first period</td>
<td>b. are very unreactive</td>
</tr>
<tr>
<td>20. second period</td>
<td>c. have unpredictable properties</td>
</tr>
<tr>
<td>21. Group 2 elements</td>
<td>d. has one more electron than sodium</td>
</tr>
<tr>
<td>22. magnesium</td>
<td>e. have loosely bound valence electrons</td>
</tr>
<tr>
<td>23. oxygen</td>
<td>f. has only one electron</td>
</tr>
<tr>
<td>24. noble gases</td>
<td>g. contains two elements</td>
</tr>
<tr>
<td>25. transition elements</td>
<td>h. have two valence electrons</td>
</tr>
<tr>
<td>26. metals</td>
<td>i. tend to gain electrons in chemical reactions</td>
</tr>
<tr>
<td>27. nonmetals</td>
<td>j. contains eight elements</td>
</tr>
</tbody>
</table>

Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

28. A Lewis electron dot structure shows the total number of electrons in the atoms of an element.
T

29. The electron dot structure for a metal is likely to have one, two, or three electrons.
T

30. An element with an electron dot structure containing only one electron is likely to be found in Group 7 of the periodic table.
F

31. Copper is a metal used in electrical circuits and in the manufacture of the alloy known as steel.
T

32. Steel surfaces are sometimes plated with chromium to protect them from corrosion.
T

33. Metalloids, such as silicon, are widely used in the manufacture of semiconductors.
F

34. Pure silicon conducts an electrical current very well.
T

35. The conductivity of silicon can be improved by doping it with other materials.
T
4.1 The Variety of Compounds

Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

1. Sodium chloride is commonly known as table salt.

2. The most important source of sodium chloride is sea water.

3. Solid sodium chloride conducts an electrical current.

4. Elemental sodium is a silvery-white metal.

5. Sodium metal is normally stored under water.

6. Chlorine is one of the most reactive of all elements.

7. Carbon dioxide gas changes from a liquid to a solid at about –80°C.

8. The science of organic chemistry is concerned with compounds that contain silicon.

9. Oxygen makes up more than half of the Earth’s air.

10. Hydrogen does not burn, but it is the gas that ordinarily supports the burning of other substances.

11. At –253°C, hydrogen changes from a gas to a liquid.

12. In general, compounds have properties that are the same as the properties of the elements of which they are composed.
From the following list of elements and compounds, select the one that best fits each of the descriptions below. Each item should be used more than once.

a. sodium  
b. chlorine  
c. sodium chloride  
d. carbon dioxide  
e. carbon  
f. oxygen  
g. hydrogen  
h. water

13. Freezes at 0°C.
14. Covers approximately 70 percent of Earth's surface.
15. Is a colorless gas of low mass that is rarely found uncombined.
16. Is a pale-green poisonous gas.
17. Is the main constituent of charcoal.
18. In its solid form, is called dry ice.
19. Has crystals shaped like tiny cubes.
20. Is produced when carbon burns in air.
21. Is a metal that is soft enough to be cut with a knife.
22. Is the most abundant element in Earth's crust.
23. Along with silicon, makes up sand.
24. Is often called the universal solvent.
25. Is the most abundant element in the universe.
26. Is a common source of heat.
27. Is used as a disinfectant.
28. Makes up about 0.03 percent of the atmosphere.
29. Melts at close to the boiling point of water.
30. Is the lightest of all elements.
31. Can be obtained by the evaporation of sea water.
32. Is located in the upper-left-hand corner of the periodic table.
When it reacts with a fluorine atom, a potassium atom loses one electron, forming a(n) (1) ________. Fluorine gains the electron and the charged atoms attract each other. This attraction is called a(n) (2) ________. The type of compound formed in this reaction, potassium fluoride, is called a(n) (3) ________. As a result of this reaction, the atoms of both potassium and fluorine have a stable set of outer electrons, an arrangement known as a(n) (4) ________. The statement that predicts that potassium will become stable by losing one electron and that fluorine will become stable by gaining one electron is the (5) ________. The regular, repeating arrangement in potassium fluoride is called a(n) (6) ________. Potassium fluoride, like other compounds of the same general type, is a(n) (7) ________, which is a substance that conducts an electric current when melted or dissolved in water.

In contrast to potassium fluoride, nitrogen monoxide is a(n) (8) ________ because nitrogen atoms in it share electrons with oxygen atoms in a kind of bond known as a(n) (9) ________. In contrast to potassium fluoride, the smallest unit of nitrogen monoxide is a(n) (10) ________. The force of attraction between particles, which is called (11) ________, is very different in these two compounds.

Both potassium fluoride and nitrogen monoxide are represented by a set of chemical symbols that represent their composition. The (12) ________ for potassium fluoride, for example, is KF, and for nitrogen monoxide, is NO.
In the spaces provided below, tell how the terms in each of the following pairs are different from each other.

13. ionic bond / covalent bond

14. ion / ionic bond

Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

15. Argon is a noble gas element.

16. The stability of the noble gas elements other than helium is a result of their having eight valence electrons.

17. Calcium has two valence electrons, and to become stable, it must gain two more electrons.

18. An ion is an atom or group of atoms that is charged because it has lost or gained one or more protons.

19. Ionically bonded compounds tend to be brittle.

20. The formula C₃H₈ tells you that this compound contains three carbon atoms and eight hydrogen atoms.

21. Covalent bonds involve electrons shared between two atoms.

22. In the electron dot structure H : Cl⁻, the pair of dots between the H and the Cl means that the hydrogen and chlorine atoms transfer a pair of electrons between them.

23. Two atoms cannot share more than one pair of electrons between them.

24. In general, ionic compounds are more likely to dissolve in water than are covalent compounds.

25. Ionic compounds conduct an electric current in the molten state.

26. The forces of attraction between molecules tend to be strong.

27. Sugar is an example of a covalent compound.
Write the word or phrase that best completes each of the following sentences or answers each question.

1. The charge on an ion is the same as the ________________ of that ion.
2. A compound consisting of two elements is called a(n) ________________.
3. A(n) ________________ is an ion containing more than one element.
4. The “H₂O” portion of the formula BaCl₂ • H₂O indicates that this compound is a(n) ________________.
5. Table salt sometimes becomes damp as it absorbs water from the air, indicating that table salt is a(n) ________________ substance.
6. A(n) ________________ substance takes up so much water from the air that it forms a liquid solution.
7. When hydrated copper sulfate is heated, it loses its water of hydration and becomes ________________ copper sulfate.
8. A(n) ________________ is the combination of chemical symbols that represents the simplest possible ratio of ions in a compound.
9. Magnesium bromide (MgBr₂) is one of the most abundant compounds found in sea water. From its formula, answer the following questions about this compound.
   a. What is the oxidation number of each ion in the compound?
      ________________
   b. What would be the formula for the dihydrate of magnesium bromide?
      ________________
   c. How would you express the following, using chemical symbols: “three formula units of magnesium bromide”?
      ________________
10. In the chemical formula of a binary ionic compound, the last part is ________________.
For each of the following formulas, write true if the formula is correct or change the formula to make it correct.

11. NACl
12. AlF$_3$
13. K$_3$PO$_4$
14. CaNO$_3$
15. BaCl$_2$, 2H$_2$O
16. FLi
17. MgSO$_4$
18. Ca$_2$C$_2$H$_3$O$_2$
19. K$_2$Cr$_2$O$_7$
20. Mgl

Write the correct name for each of the compounds in questions 11 - 20 above.

21. 11: ______________________
22. 12: ______________________
23. 13: ______________________
24. 14: ______________________
25. 15: ______________________
26. 16: ______________________
27. 17: ______________________
28. 18: ______________________
29. 19: ______________________
30. 20: ______________________
5.2 Molecular Substances

For each of the properties listed below, write I for ionic compound or M for molecular substance to indicate which kind of substance is more likely to have that property.

I. low melting point
II. brittle
III. conducts an electric current
IV. forms hydrates
V. weak interparticle forces
VI. contains carbon
VII. contains bonds involving gain and loss of electrons
VIII. can contain a polyatomic ion
IX. usually not very soluble in water
X. contains bonds in which atoms share electrons

For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. describes molecular substances</td>
<td>a. methane</td>
</tr>
<tr>
<td>12. example of allotropes</td>
<td>b. water</td>
</tr>
<tr>
<td>13. describes organic compounds</td>
<td>c. covalent bonding</td>
</tr>
<tr>
<td>14. simplest hydrocarbon</td>
<td>d. contain carbon</td>
</tr>
<tr>
<td>15. common inorganic compound</td>
<td>e. oxygen and ozone</td>
</tr>
</tbody>
</table>
Fill in the missing name or formula for each compound.

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.</td>
<td>Ca(OH)₂</td>
</tr>
<tr>
<td>17. sulfuric acid</td>
<td></td>
</tr>
<tr>
<td>18. ammonia</td>
<td></td>
</tr>
<tr>
<td>19. SO₂</td>
<td></td>
</tr>
<tr>
<td>20. Na₂O</td>
<td></td>
</tr>
<tr>
<td>21. CCl₄</td>
<td></td>
</tr>
<tr>
<td>22. diphosphorus pentoxide</td>
<td></td>
</tr>
<tr>
<td>23. hydrochloric acid</td>
<td></td>
</tr>
<tr>
<td>24. octane</td>
<td></td>
</tr>
<tr>
<td>25. FeBr₃</td>
<td></td>
</tr>
</tbody>
</table>

In the space provided, tell why each formula or name of a compound is incorrect.

26. NaK

27. sulfur oxide

28. I₂Ca

29. copper chloride

30. NH₄SO₄
In each blank, write the word or phrase that best completes the following passage.

When a piece of magnesium metal is added to dilute hydrochloric acid, fizzing occurs and hydrogen gas is released from the mixture. The fizzing is evidence that a(n) (1) _________________ has occurred between magnesium and hydrochloric acid. The name given to either magnesium or hydrochloric acid in this case is (2) _________________, and the hydrogen gas that is released is called a(n) (3) _________________ of the reaction. Some other indications that reactions have occurred might be change of color or (4) _________________, or formation of a solid (5) _________________. If a thermometer is placed into a mixture undergoing a reaction, you might observe that the temperature has gone up or down, indicating that (6) _________________ was being released or absorbed.

The shorthand form by which a reaction is represented is called a(n) (7) _________________. In using this method of representation, you must satisfy the (8) _________________, a principle that states that matter is neither created nor destroyed. In order to satisfy this principle, you normally select the proper numerical (9) _________________ to indicate the number of units of each substance taking part in the chemical change.

In the space provided, express in words each of the numbered terms or symbols in the following chemical equation.

\[ \text{Mg(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{H}_2\text{(g)} \]

10. Mg _________________
11. (s) _________________
12. + _________________
13. 2 _________________
14. HCl(aq) _________________
15. (aq) _________________
16. → _________________
17. MgCl\(_2\) (aq) _________________
18. H\(_2\) _________________
19. (g) _________________
Write a word equation and a balanced chemical equation for each of the reactions described below.

20. Aluminum metal burns in pure oxygen gas to produce solid aluminum oxide.
   word equation: ____________________________________________________________
   chemical equation: ______________________________________________________

21. When solid mercury(II) oxide is heated, it breaks down to form liquid mercury and oxygen gas.
   word equation: __________________________________________________________
   chemical equation: ______________________________________________________

22. The addition of a solution of ammonium sulfate to a solution of lead(II) nitrate results in the formation of ammonium nitrate, which remains in solution, and lead(II) sulfate, which settles out of solution as a solid.
   word equation: __________________________________________________________
   chemical equation: ______________________________________________________

23. Copper metal and iron(II) nitrate in solution are formed when iron metal is added to a solution of copper (II) nitrate.
   word equation: __________________________________________________________
   chemical equation: ______________________________________________________

24. Hydrogen sulfide gas reacts with pure oxygen gas to form water vapor and solid particles of sulfur.
   word equation: __________________________________________________________
   chemical equation: ______________________________________________________

Balance each of the following chemical equations.

25. _____ P(s) + _____ O₂(g) → _____ P₄O₁₀(s)
26. _____ Fe(OH)₃(s) → _____ Fe₂O₃(s) + _____ H₂O(g)
27. _____ Na₂CO₃(aq) + _____ Ca(OH)₂(aq) → _____ NaOH(aq) + _____ CaCO₃(s)
28. _____ K₃PO₄(aq) + _____ MgCl₂(aq) → _____ Mg₃(PO₄)₂(s) + _____ KCl(aq)
29. _____ Mg(HCO₃)₂(aq) + _____ HCl(aq) → _____ MgCl₂(aq) + _____ H₂O(l) + _____ CO₂(g)
30. _____ Bi(NO₃)₃(aq) + _____ CaI₂(aq) → _____ BiI₃(s) + _____ Ca(NO₃)₂(aq)
31. _____ Cu(s) + _____ H₂SO₄(aq) → _____ CuSO₄(aq) + _____ H₂O(l) + _____ SO₂(g)
Choose the correct symbol listed below to describe each of the chemical reactions listed in questions 1–15. Also write a balanced chemical equation for each reaction.

S = synthesis  SD = single displacement
D = decomposition  DD = double displacement
C = combustion

1. _____ zinc(s) + silver nitrate(aq) → silver(s) + zinc nitrate(aq)
   balanced equation: ___________________________________________________________________

2. _____ iron (III) hydroxide(s) → iron (III) oxide(s) + water(g)
   balanced equation: ___________________________________________________________________

3. _____ ammonia(g) + sulfuric acid(aq) → ammonium sulfate(aq)
   balanced equation: ___________________________________________________________________

4. _____ magnesium(s) + nitric acid(aq) → magnesium nitrate(aq) + hydrogen(g)
   balanced equation: ___________________________________________________________________

5. _____ calcium nitrate(s) + hydrochloric acid(aq) → nitric acid(aq) +
   calcium chloride(aq)
   balanced equation: ___________________________________________________________________

6. _____ Na(s) + H₂O(l) → NaOH(aq) + H₂(g)
   balanced equation: ___________________________________________________________________

7. _____ CO(g) + O₂(g) → CO₂(g)
   balanced equation: ___________________________________________________________________

8. _____ FeS(s) + HCl(aq) → FeCl₂(aq) + H₂S(g)
   balanced equation: ___________________________________________________________________
9. _____ \( \text{NaNO}_3(s) \rightarrow \text{NaNO}_2(s) + \text{O}_2(g) \)  
   balanced equation: ________________________________________________________

10. _____ \( \text{CH}_4(g) + \text{O}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O}(g) \)  
    balanced equation: ________________________________________________________

11. _____ \( \text{Fe}(s) + \text{CuNO}_3(aq) \rightarrow \text{Cu}(s) + \text{Fe(NO}_3)_2(aq) \)  
    balanced equation: ________________________________________________________

12. _____ \( \text{KI}(aq) + \text{Cl}_2(g) \rightarrow \text{KCl}(aq) + \text{I}_2(aq) \)  
    balanced equation: ________________________________________________________

13. _____ \( \text{Al}(s) + \text{S}(s) \rightarrow \text{Al}_2\text{S}_3(s) \)  
    balanced equation: ________________________________________________________

14. _____ \( \text{KClO}_3(s) \rightarrow \text{KCl}(s) + \text{O}_2(g) \)  
    balanced equation: ________________________________________________________

15. _____ \( \text{C}_4\text{H}_{10}(g) + \text{O}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O}(g) \)  
    balanced equation: ________________________________________________________
6.3 Nature of Reactions

In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

a. activation energy  
b. catalyst  
c. concentration  
d. enzyme  
e. equilibrium  
f. inhibitor  
g. insoluble  
h. limiting reactant  
i. soluble

1. The reaction \( \text{N}_2(g) + 3 \text{H}_2(g) \rightleftharpoons 2 \text{NH}_3(g) \) can occur only when nitrogen molecules and hydrogen molecules have sufficient energy.

2. The amounts of nitrogen, hydrogen, and ammonia in this reaction do not change.

3. The rate of this reaction can be increased by adding a mixture of iron, potassium oxide, and aluminum oxide. The added materials are not permanently changed.

4. The amount of ammonia produced by this reaction would be small if only a small amount of nitrogen were used.

5. It is important to know the amount of each substance per unit volume.

6. Some substances needed in the body of a living thing speed up reactions but are not used up.

7. Some materials slow reactions down.

8. Some materials cannot be made to dissolve in water.

9. Some materials can dissolve in water.

For the chemical reaction described by the equation below, write three sentences that tell how to make the reaction occur more rapidly or more slowly. In each sentence, use a term from the list of nine words you worked with above.

\[ A + B \rightleftharpoons C + D \]

More rapidly:

10. ________________________________

11. ________________________________
12. ______________________________________________________________________
   ______________________________________________________________________
   More slowly:
13. ______________________________________________________________________
   ______________________________________________________________________
14. ______________________________________________________________________
   ______________________________________________________________________
15. ______________________________________________________________________
In the spaces provided below, contrast terms in each pair.

1. Dalton atom and Rutherford atom

2. Energy level and sublevel

3. Frequency and wavelength:

4. Spectral lines from transitions between energy levels and spectral lines from transitions between sublevels

5. Maximum number of electrons in energy level 2 and in energy level 3

6. Electron cloud and orbital

7. \textit{s} orbital and \textit{p} orbital

8. Emission spectra and energy levels

9. Number of valence electrons and periodic table group number

10. Number of sublevels in energy level 2 and number of sublevels in energy level 3
Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

11. Atoms of elements in the second row of the periodic table contain 1s, 2s, and 2p electrons.

12. The Heisenberg uncertainty principle says that it is impossible to determine the position and the mass of an electron in an atom at the same time.

13. The theory of the atom developed by Niels Bohr was valid for only one kind of atom, the helium atom.

14. No s orbital can ever have more than two electrons in it.

15. No p orbital can ever have more than six electrons in it.

16. When an electron jumps from energy level 1s to energy level 2s, it absorbs the same amount of energy as it would release in falling from energy level 2s to energy level 1s.

17. The maximum number of electrons in sublevel 4f is 32.

18. An orbital is a space in which the probability of finding an electron is about 50 percent.

19. Two orbitals can overlap with each other because they are filled primarily with empty space.

20. The s orbitals in an atom are spherical in shape and are the same size.

21. The farther an electron falls to its original level, the more toward the red end of the spectrum the color given off will be.

22. Electrons in an atom are distributed in a way that makes an arrangement with the lowest energy.

23. The overlap of orbitals results in the general shape of a sphere.

24. Electrons with the least amount of energy are farthest from the nucleus.
7.2 The Periodic Table and Atomic Structure

For each element in Column A, write the letter of the matching electron configuration in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrogen</td>
<td>a. [He]2s²2p¹</td>
</tr>
<tr>
<td>lithium</td>
<td>b. [He]2s²2p³</td>
</tr>
<tr>
<td>boron</td>
<td>c. 1s²2s²2p⁶</td>
</tr>
<tr>
<td>carbon</td>
<td>d. [Ar]4s²</td>
</tr>
<tr>
<td>nitrogen</td>
<td>e. [Ne]3s²3p³</td>
</tr>
<tr>
<td>fluoride</td>
<td>f. 1s³</td>
</tr>
<tr>
<td>neon</td>
<td>g. [Ne]3s²3p⁵</td>
</tr>
<tr>
<td>sodium</td>
<td>h. 1s²2s²2p⁶3s²3p¹</td>
</tr>
<tr>
<td>aluminum</td>
<td>i. [He]2s²2p²</td>
</tr>
<tr>
<td>phosphorus</td>
<td>j. [He]2s²2p⁵</td>
</tr>
<tr>
<td>chlorine</td>
<td>k. [He]2s¹</td>
</tr>
<tr>
<td>calcium</td>
<td>l. 1s²2s²2p⁶3s¹</td>
</tr>
</tbody>
</table>

In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

13. In the electron configuration of an element, the first electron always goes into ________.
   a. the 1s orbital       c. the nucleus
   b. the 2s orbital       d. an orbital that depends upon the element

14. The correct order for filling orbitals in an atom is ________.
   a. 1s, 2s, 3s, 4s       c. 1s, 2s, 3s, 2p
   b. 1s, 2s, 2p, 3s       d. 1s, 1p, 2s, 2p

15. Groups 3 through 12 in the periodic table are designated as the ________.
   a. s region       c. d region
   b. p region       d. f region
16. The correct abbreviated designation for the electron configuration 1s²2s²2p⁶ is ________.
   a. [H]  c. [Ne]
   b. [He]  d. [Ar]

17. Any element in Group 2 of the periodic table will have an electron configuration that ends in ________.
   a. 1s  c. s¹
   b. 2s  d. s²

18. All noble gases other than helium have an electron configuration that ends in ________.
   a. s²  c. d¹
   b. p⁶  d. f¹⁴

19. The electron sublevel that fills in elements that make up the lanthanide series is the ________.
   a. 2f sublevel  c. 4f sublevel
   b. 3f sublevel  d. 5f sublevel

20. Going down Group 1 of the periodic table 1, which of the following shows the relative size of the outermost s orbital?
   a. 1s > 2s > 3s  c. 1s = 2s = 3s
   b. 1s < 2s < 3s  d. 1s > 2s < 3s

21. When iron exhibits an oxidation number of 3⁺, which electrons has it lost?
   a. one each of 1s, 2s, and 3s  c. two 4s and one 4p
   b. one each of 2s, 3s, and 4s  d. two 4s and one 3d

22. The changes that take place in the electron configuration of the elements between scandium and zinc in the fourth row of the periodic table mainly involve changes in the ________.
   a. 4p sublevel  c. 3d sublevel
   b. 4d sublevel  d. 3f sublevel
8.1 Main Group Elements

From the following list of elements, select the one that best fits each of the descriptions below.

- aluminum
- iodine
- phosphorus
- boron
- magnesium
- potassium
- calcium
- nitrogen
- sulfur
- fluorine
- oxygen
- tin

1. The most abundant element on Earth
2. Needed for proper functioning of the thyroid gland
3. Reacts violently with water
4. Used to make alloys such as bronze, solder, and pewter
5. A Group 15 element used in making matches
6. An important element in bones and teeth
7. Extracted from underground mines with hot water
8. Its compounds help prevent tooth decay.
9. Its atoms are found at the center of chlorophyll molecules.
10. The most abundant metallic element on Earth
11. Used in the production of water softeners and certain types of glass
12. Obtained from liquid air by fractional distillation

Answer the following questions.

13. Why do elements in the same period have properties that are different from one another?

14. In general, how does atomic radius change across a period from left to right? Why?
15. How does the size of a metallic atom change when it loses electrons to become a positive ion? ________________________________________________________________________________________

16. How does the size of a metallic atom change when it gains electrons to become a negative ion? ________________________________________________________________________________________

17. What type of configuration do elements tend toward as they react? ________________________________________________________________________________________

18. Why does boron not always continue the Period 2 pattern of reacting by losing electrons, as do beryllium and lithium? ________________________________________________________________________________________

Compare each of the following pairs of elements, atoms, or ions by underlining the correct word in the pair.

19. Cesium is more/less active than sodium.

20. Sodium is more/less active than magnesium.

21. An aluminum ion has a larger/smaller radius than a magnesium ion.

22. An aluminum ion has a larger/smaller radius than a gallium ion.

23. Carbon has more/fewer valence electrons than does oxygen.

24. An atom of fluorine has a larger/smaller radius than does an atom of iodine.

25. Sulfur is more/less active than selenium.

26. Antimony is more/less metallic than is arsenic.

27. A halogen is more/less likely to occur in the free state than are members of the nitrogen family.

28. An atom of scandium is larger/smaller than an atom of titanium.
8.2 Transition Elements

From the following list of elements, select the one that best fits each of the descriptions below.

- americium
- cerium
- chromium
- plutonium
- cobalt
- iron
- mercury
- silver
- uranium
- zinc

1. Used as a power source in heart pacemakers
2. The major component of steel
3. The element most commonly used in making barometers
4. Traditionally used in the manufacture of jewelry
5. Frequently added to steel to make a harder, stronger product
6. Used in the manufacture of ionizing smoke detectors
7. Alloyed with copper to make brass
8. Makes up about half of the alloy known as misch metal
9. A naturally occurring element used as a nuclear fuel
10. Like iron and nickel, is naturally magnetic

In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

11. A transition element known for its excellent ability to conduct an electric current is ________ .
   a. iron  
   b. copper  
   c. uranium  
   d. silicon

12. The element with the highest melting point is ________ .
   a. iron  
   b. platinum  
   c. tungsten  
   d. iridium

13. Which of the following elements has the lowest melting point?
   a. sodium  
   b. copper  
   c. gallium  
   d. mercury
14. Among the elements listed below, the one likely to have more than one oxidation state in compounds is ________.
   a. sodium  c. iron
   b. fluorine  d. neon

15. An impure form of iron produced in a blast furnace is known as ________.
   a. slag  c. native steel
   b. pig iron  d. galvanized steel

16. The purpose of heat-treating steel is to make it ________.
   a. harder  c. shinier
   b. smoother  d. more resistant to corrosion

17. A group of elements commonly used as catalysts to speed up chemical reactions is the ________.
   a. iron triad  c. lanthanides
   b. actinides  d. platinum group

18. The element that is named because of the colorful compounds it forms is ________.
   a. iron triad  c. copper
   b. chromium  d. lanthanum

19. The name rare earth elements is sometimes used for the ________.
   a. iron triad  c. actinides
   b. lanthanides  d. inner transition elements

20. The only synthetic element in the lanthanide series is ________.
   a. cerium  c. francium
   b. plutonium  d. promethium

21. The two elements used as nuclear fuels are uranium and ________.
   a. plutonium  c. americium
   b. thorium  d. californium

22. Elements in which the 5f sublevel is filling with electrons are the ________.
   a. actinides  c. transition elements
   b. lanthanides  d. iron triad
For each item in Column A, write the letter of the matching item in Column B.

**Column A**

1. ________ Ability to be drawn into a thin wire
2. ________ A “sea of electrons”
3. ________ Electrons shared unequally between two atoms
4. ________ The ability of a substance to carry an electric current
5. ________ The measure of an atom’s ability to attract electrons in a chemical bond
6. ________ Ability to be hammered or rolled into a thin sheet
7. ________ A decrease in the attraction exerted by an atomic nucleus on valence electrons
8. ________ $\Delta EN = 0.3$
9. ________ $\Delta EN = 3.0$
10. ________ Symbolized by $\delta$

**Column B**

a. shielding effect
b. partial charge
c. ductility
d. ionic bond
e. nonpolar covalent bond
f. polar covalent bond
g. metallic bond
h. malleability
i. electronegativity
j. conductivity

Use a table of electronegativities to calculate the value of $\Delta EN$ for each of the following pairs of atoms and predict the type of bond formed between them in each case.

11. lithium and sulfur
    $\Delta EN = \underline{\phantom{0.3}}$ Type of bond: ______________________
12. carbon and bromine
    $\Delta EN = \underline{\phantom{3.0}}$ Type of bond: ______________________
13. fluorine and silicon
    $\Delta EN = \underline{\phantom{3.0}}$ Type of bond: ______________________
14. magnesium and nitrogen
    $\Delta EN = \underline{\phantom{3.0}}$ Type of bond: ______________________
15. hydrogen and germanium
    $\Delta EN = \underline{\phantom{3.0}}$ Type of bond: ______________________
In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

16. A value of 0.3 for ∆EN of atoms of two elements suggests that the bond between them is ________.
   a. ionic c. metallic
   b. nonpolar covalent d. polar covalent

17. A bond is considered to be ionic if the difference in electronegativities between the two atoms of which it is formed is ________.
   a. greater than 0 c. between 0.5 and 2.0
   b. greater than 2.0 d. less than 2.0

18. In ∆EN, the Greek letter delta (Δ) stands for ________.
   a. electronegativity c. bond type
   b. difference d. charge

19. The valence electrons in a metal ________.
   a. remain with individual atoms c. form ionic bonds
   b. form covalent bonds d. are shared among all atoms

20. Diatomic molecules of elements always have ________.
   a. ionic bonds c. metallic bonds
   b. nonpolar covalent bonds d. polar covalent bonds

From the following list of terms, select the one that best completes each of the sentences below.

   a. increase b. decrease c. stay the same

In moving from left to right in a row of the periodic table, electronegativities tend to (21) ________ and the shielding effect tends to (22) ________.

In moving from top to bottom in a column near the right edge of the periodic table, electronegativities tend to (23) ________ and the shielding effect tends to (24) ________.

In moving from bottom to top in a column near the left edge of the periodic table, electronegativities tend to (25) ________ and the shielding effect tends to (26) ________.
Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

1. The hydrogen molecule is linear.
2. In a water molecule, four electron pairs are involved in covalent bonds.
3. The approximately tetrahedral arrangement of electron pairs in a water molecule allows the electrons to be as far from each other as possible.
4. The three-dimensional shape of a molecule is represented by a molecular formula.
5. The angle between the two bonds in a water molecule is 109.5°.
6. Triatomic molecules are always bent.
7. A double bond is a covalent bond in which two electrons are shared between atoms.
8. Four electron clouds surround the carbon atom in a carbon dioxide molecule.
9. A methane molecule can be pictured as a tetrahedron.
10. Methane is an example of an alkane, a compound whose molecules contain only carbon, hydrogen, and single bonds.
11. Ethane and ethene have molecular shapes that are the same.
12. The two carbons in ethyne are joined by double bonds.
13. Ethyne is the simplest member of a family of organic compounds known as alkynes.
14. A nonpolar molecule is one with a positive and a negative end.
15. Another name for a polar molecule is a dipole.
16. Polar molecules tend to be attracted to each other.
17. The melting point of compounds that have polar molecules tends to be lower than the melting point of compounds that have nonpolar molecules.
In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

18. The bond in a nitrogen molecule is _________.
   a. polar covalent   c. metallic
   b. nonpolar covalent d. ionic

19. Hydrogen chloride is a(n) ________ substance.
   a. polar   c. metallic
   b. nonpolar d. ionic

20. In a water molecule, the two covalent bonds are _________.
   a. in a straight line   c. nonpolar
   b. at 105° to each other d. at 109.5° to each other

21. Of the four pairs of valence electrons in the water molecule, how many pairs are used in bonding?
   a. four   c. two
   b. three d. one

22. Of the four pairs of valence electrons in the water molecule, how many pairs contribute to the shape of the molecule?
   a. four   c. two
   b. three d. one

23. The relatively high boiling point of water is due to _________.
   a. its nonpolar bonds   c. the polarity of the water molecule
   b. the equal electronegativity d. the nonpolarity of the water molecule of oxygen and hydrogen atoms

24. The presence of a double bond in a molecule means that _________.
   a. the molecule is polar   c. the molecule has a high boiling point
   b. the molecule is nonpolar d. two pairs of electrons are shared

Based on the molecules you studied in this chapter, predict the geometric shape of the following molecules and whether each is polar or nonpolar.

25. hydrogen bromide (HBr)  
   shape: ________________  
   polarity: ________________

26. phosphine (PH₃)  
   shape: ________________  
   polarity: ________________

27. silane (SiH₄)  
   shape: ________________  
   polarity: ________________
From the following list of terms, select the one that best completes each sentence.

- ideal gas
- amorphous material
- solid
- kinetic theory
- gas
- Brownian motion
- crystal lattice
- plasma
- liquid crystal
- liquid
- ideal gas

The (1) _____________ states that submicroscopic particles of matter are in constant motion. (2) _____________, which is the constant, random movement of tiny chunks of matter, provides evidence for this model. In a(n) (3) _____________, the particles are fixed in place, resulting in the formation of a highly organized structure known as a(n) (4) _____________. The particles that make up a (5) _____________, on the other hand, can flow, and matter in this state has an indefinite shape but a definite volume. A(n) (6) _____________ has no definite volume or shape and is compressible. A(n) (7) _____________ is one in which the particles undergo elastic collisions.

Some less familiar forms of matter also exist. In a(n) (8) _____________, for example, particles may consist of rod-like molecules that have a rigid structure in only one or two dimensions. In comparison, a(n) (9) _____________ appears to be solid, but has no well-organized structure. Finally, the most common form of matter in the universe is (10) _____________, an ionized gas.

In the space provided, write the letter of the form of matter that best fits each description.

- solid (S)
- gas (G)
- liquid crystal (LC)
- liquid (L)
- plasma (P)
- amorphous material (AM)

11. _________ is used in calculator and watch displays.

12. _________ takes the shape of its container but has a definite volume.
13. _______ completely fills a container.
14. _______ is rigid, with a definite crystalline structure.
15. _______ retains an organized structure in one or two dimensions when melted.
16. _______ appears to be a solid, but has a haphazard structure.
17. _______ is formed at very high temperatures.
18. _______ is rare on Earth, but is in fluorescent lamps.
19. _______ flows and can be compressed to a smaller volume.
20. _______ maintains its volume but flows.

Answer the following questions.

21. Gases can be compressed easily. Liquids and solids can hardly be compressed at all. What statement about the particles that make up these states of matter can you make on the basis of these facts? ________________

22. Define pressure, and explain how gases are able to exert pressure.

________________________________________________________________________________________

________________________________________________________________________________________

23. Use the kinetic model to describe the behavior of liquids. ________________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

24. Explain what plasmas are and how they are formed. ________________

________________________________________________________________________________________

________________________________________________________________________________________
10.2 Kinetic Energy and Changes of State

Explain how the terms in the following pairs are related to each other.

1. Kelvin and Celsius temperatures

2. temperature and the speed of particles

3. kinetic energy and mass of a particle, assuming constant speed

4. evaporation and sublimation

5. rate of diffusion and speed of particles

6. evaporation and boiling

7. vapor pressure and tendency to evaporate

8. interparticle forces and boiling point, assuming similar molecular mass

9. absolute zero and 0 K

10. atmospheric pressure and boiling point of a given liquid
Answer the following questions.

11. What is the value of each of the following temperature measurements on the Kelvin scale?
   a. 78°C ________________________________
   b. -64.3°C _______________________________

12. What is the value of each of the following temperature measurements on the Celsius scale?
   a. 49 K ________________________________
   b. 432 K _______________________________

13. Wet laundry hung outside on a cold day will dry even if the temperature is below freezing. How can you explain this fact? ________________________________

14. What is meant by the fact that the heat of vaporization of water is \(2.26 \times 10^6\) J/kg? Given that this quantity has the value \(2.26 \times 18\) J/kg for water, how much energy will be needed to vaporize 175 g of water? ________________________________

15. Describe the shape of a graph of temperature versus time for a solid being warmed, then melted to a liquid, that then is warmed to its boiling point and vaporized. Account for the shape. ________________________________

11.1 Gas Pressure

In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

1. At constant temperature and volume, the pressure exerted by a gas on the walls of a container is directly proportional to ________.
   a. the number of particles       c. both the number of particles and mass
   b. the mass of the gas           d. neither the number of particles nor the mass

2. If the volume, number of particles and mass of a gas are not changed, the pressure of a gas is directly proportional to its ________.
   a. Celsius temperature          c. Boyle temperature
   b. Kelvin temperature           d. Fahrenheit temperature

3. The barometer was invented by ________.
   a. Robert Boyle                c. Evangelista Torricelli
   b. Jacques Charles             d. Augustus Sphygmanus

4. The SI unit for measuring pressure is the ________.
   a. atmosphere                  c. kilopascal
   b. psi                          d. pascal

5. At sea level, atmospheric pressure is equal approximately to ________.
   a. 101.3 kPa                    c. 1000 atm
   b. 14.7 mm Hg                   d. 101.3 Pa

6. The name of the device used to measure blood pressure is the ________.
   a. barometer                    c. sphygmanometer
   b. pressure gauge               d. pascal meter

Convert each of the measurements below, as directed.

7. Convert each of the following measurements to its equivalent in mm Hg.
   a. 1.2 atm ________________
   b. 44.2 kPa ________________

8. Convert each of the following measurements to its equivalent in atm.
   a. 785.2 mm Hg ________________
   b. 132.1 kPa ________________
9. Convert each of the following measurements to its equivalent in kPa.
   a. 790.3 mm Hg
   b. 1.442 atm

Answer the following questions.

10. If you push your finger into a balloon and then take your finger away, the “dent” in the balloon does not remain. Why?

11. Why is atmospheric pressure lower on the top of a mountain than it is at sea level?

12. List three ways to raise the air pressure inside a balloon.

13. If you puncture a cylinder of carbon dioxide gas, why does the gas rush out instead of flowing or leaking out?

14. The valve on a tank of pressurized oxygen is opened and the oxygen rushes out. After oxygen gas stops flowing from a tank, some gas remains inside. Explain what determines how much gas is still in the tank.
11.2 The Gas Laws

Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

1. The person who discovered the law expressing the quantitative relationship between the pressure and volume of a gas was Robert Boyle.
2. The term direct proportion means that two related variables always increase together or always decrease together.
3. The graph of a direct proportion is always a curved line.
4. If the volume of a gas is 10 L at 1.5 atm, then the volume will be 5 L at 0.75 atm assuming the pressure does not change.
5. Jacques Charles discovered the quantitative relationship between the temperature and volume of a gas while doing research on hot-air balloons.
6. If the volume of a gas is 10 L at 100 K, then its volume will be 5 L at 200 K assuming the pressure does not change.
7. To solve problems involving Charles' Law, one must always express the temperature in degrees Celsius.
8. The term standard temperature means zero degrees kelvin.
9. The volume of a gas whose temperature is doubled and whose pressure is doubled will increase four times.
10. According to the law of combining gas volumes, the ratio in which gases combine or decompose is always a small whole number ratio.
11. According to Avogadro's principle, equal volumes of gases at the same temperature and pressure contain equal numbers of particles.
12. In the decomposition of water, the ratio of volumes of hydrogen to oxygen produced is 1:1.

Solve the following problems.

13. A balloon contains 750.0 mL of hydrogen gas at a pressure of 700.0 mm Hg. What will be the volume of that gas if the pressure is increased to 800.0 mm Hg?
14. A sample of 220.0 mL of neon gas is enclosed in a cylinder with a piston that can move up and down with changes in temperature. If the gas is at 10.0°C, and if the pressure on the gas does not change, what will be the volume of the gas if the temperature is increased by 90.0°C?

15. A scientist wishes to compress 50.0 mL of ammonia gas at normal atmospheric pressure to a volume of 1.0 mL. What pressure in atmospheres is necessary?

16. In a study on carbon dioxide gas, a scientist begins with 30.0 mL of the gas at a temperature of 14°C. She lowers the temperature of the gas until its volume is reduced to 22.0 mL. The pressure on the gas is not changed during the experiment. To what temperature in °C was the gas lowered to reach this volume?

17. A sample of xenon gas occupying 10.0 mL is collected in a laboratory at 27°C and 1.25 atm. What is the volume of the gas at standard conditions?

18. A researcher is interested in finding the effects of reducing both the pressure and the temperature on a sample of uranium hexafluoride gas. If the gas occupies 6.6 L at standard conditions, what will its volume be at a –23°C and 150 mm Hg?

19. In a Boyle's law experiment, a student prepared a sample of oxygen gas on Monday and returned to study its properties on Tuesday. The volume of the gas was 75.0 mL on Monday and 70.0 mL on Tuesday. The temperature was 27°C on Monday and 25°C on Tuesday. On Tuesday, the student recorded the pressure on the gas as 4.4 atm, but forgot to record the pressure on the gas on Monday. What was that pressure in atmospheres?

20. A student studying the effects of cold temperatures on helium gas subjects a 10.0 mL sample of the gas originally at 20.0°C and 760 mm Hg to severe cooling. If the pressure on the gas rises to 800.0 mm Hg during the experiment, and the final volume of the gas is 1.0 mL, to what value in °C was the temperature reduced?
In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

1. Which of the following quantities is not a mole of the substance?
   a. 15.999 g oxygen gas
   b. 12.011 g carbon
   c. 28.014 g nitrogen gas
   d. 4.003 g helium gas

2. The mass of a mole of zinc equals the atomic mass of zinc expressed in __________.
   a. mol
   b. kilograms
   c. grams
   d. number of particles

3. The number of atoms in one mole of sodium metal is __________.
   a. 23
   b. $6.02 \times 10^{23}$
   c. $23 \div (6.02 \times 10^{23})$
   d. $(6.02 \times 10^{23}) \div 23$

4. The term molecular mass is used only for compounds __________.
   a. containing carbon
   b. consisting of ions
   c. that are covalent
   d. that do not ionize in water

5. A sample of water whose mass is 18 g represents what quantity of water?
   a. formula mass
   b. molar mass
   c. atomic weight
   d. atomic mass

6. The formula mass for aluminum chloride is __________.
   a. 62.45 u
   b. $6.02 \times 10^{23}$ u
   c. 97.9 u
   d. 133.34 u

7. Compared to the number of molecules in a mole of hydrogen gas (H₂), the number of molecules in a mole of water (H₂O) is __________.
   a. twice as many
   b. the same
   c. half as many
   d. three times as many
8. The mass of an average ruthenium atom is 8.4 times as large as the mass of an average carbon atom. What is the mass of one mole of ruthenium?
   a. 8.4 g
   b. $8.4 \times 6.02 \times 10^{23}$ g
   c. 100.9 g
   d. $8.4 \times 12 \times 6.02 \times 10^{23}$ g

9. The mass of one molecule of ammonia is its _______.
   a. molecular weight
   b. molecular mass
   c. formula mass
   d. formula unit

Solve the following problems.

10. Find the number of atoms in each of the following measurements.
   a. 10.0 g of Al _____________________________
   b. 25.9 g of F _____________________________

11. Find the molar mass of each of the following compounds.
   a. $\text{N}_2\text{O}_5$ __________________________
   b. ammonium carbonate ______________________

12. Express each of the following in grams.
   a. 0.147 mol of $\text{NH}_4\text{NO}_3$ __________________________
   b. 2.60 mol of lithium bromide __________________________

13. Convert each of the following to its equivalent in moles.
   a. 17.1 g of $\text{H}_2\text{S}$ __________________________
   b. 2.50 g of copper(II) chloride __________________________

Answer the following questions.

14. How many nitrogen atoms are in $\frac{1}{4}$ mole of nitrogen gas?

15. How many moles of oxygen atoms are in $\frac{1}{2}$ mole of $\text{Na}_2\text{O}_4$?
12.2 Using Moles

In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

1. In the equation \(2H_2 + O_2 \rightarrow 2H_2O\), the number of molecules of water formed for every one molecule of hydrogen that reacts is _______.
   a. one  
   b. two  
   c. four  
   d. one-half

2. In the equation in question 1, the number of molecules of oxygen needed to form 0.8 mol of water is _______.
   a. 0.4 mol  
   b. 0.8 mol  
   c. 0.2 mol  
   d. 1.6 mol

3. The molar volume of a gas at standard conditions is _______.
   a. 1 L  
   b. \(6.02 \times 10^{23}\) L  
   c. 22.4 L  
   d. dependent on the gas

4. In the equation that represents the ideal gas law, the only constant is _______.
   a. \(P\)  
   b. \(V\)  
   c. \(n\)  
   d. \(R\)

5. In a chemical reaction in which 35.8 g of product is predicted and only 13.2 g obtained, the percent yield is _______.
   a. \(\frac{35.8\ g}{13.2\ g} \times 100\%\)  
   b. \(\frac{13.2\ g}{35.8\ g} \times 100\%\)  
   c. \(\frac{35.8\ g}{(35.8\ g + 13.2\ g)} \times 100\%\)  
   d. \(\frac{(35.8\ g + 13.2\ g)}{35.8\ g} \times 100\%\)

6. In the compound \(FeCl_3\), the percent by mass of chlorine in the compound is _______.
   a. \(\frac{\text{mass of Cl}}{\text{mass of } FeCl_3} \times 100\%\)  
   b. \(\frac{\text{mass of } FeCl_3}{\text{mass of Cl}} \times 100\%\)  
   c. \(3 \times \frac{\text{mass of Cl}}{\text{mass of } FeCl_3} \times 100\%\)  
   d. \(\frac{\text{mass of } FeCl_3}{3} \times \frac{\text{mass of Cl}}{100\%}\)
7. If the empirical formula of a compound is HF and analysis shows its molar mass is 40 g, its molecular formula would be _______.
   a. HF
   b. H₂F₂
   c. H₃F₃
   d. H₄₀F₴₀

Solve the following problems.

8. Zinc metal reacts with hydrochloric acid according to the following equation:
   \[ \text{Zn} + 2 \text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2 \]. How many grams of hydrogen gas can be obtained if 50.0 g of zinc react completely?

9. What mass of magnesium chloride is needed to react with 145 g of silver nitrate according to the following reaction: \( \text{MgCl}_2(\text{aq}) + 2\text{AgNO}_3(\text{aq}) \rightarrow \text{Mg(NO}_3)_2(\text{aq}) + 2\text{AgCl} \)?

10. When potassium chlorate is heated, oxygen is produced according to the following reaction:
    \[ 2\text{KClO}_3 + \text{heat} \rightarrow 2\text{KCl} + 3\text{O}_2 \]. How many liters of oxygen gas at STP can be obtained if 500.0 g of potassium chlorate react completely?

11. How many liters of hydrogen gas at STP are needed to react completely with 50.0 L of chlorine gas at STP in the following reaction: \( \text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl} \)? How many liters of hydrogen chloride gas at STP are produced in the reaction?

12. What volume will 2.39 mol of carbon dioxide gas occupy at 32.5°C and 105 kPa?

13. What pressure will be needed to compress 5.00 mol of nitrogen gas at 23°C to a volume of 1.5 L?

14. A student heats 100.0 g of copper(II) sulfate pentahydrate and obtains 58.2 g of anhydrous copper(II) sulfate. What percent yield was obtained in this experiment? \( \text{CuSO}_4 \cdot 5\text{H}_2\text{O} \rightarrow \text{CuSO}_4 + 5\text{H}_2\text{O} \)

15. Find the percent composition by mass of phosphoric acid, \( \text{H}_3\text{PO}_4 \).

16. Find the empirical formula for a compound that has the following percentage composition by mass: 10.04 percent carbon; 0.84 percent hydrogen; 89.12 percent chlorine.
13.1 Uniquely Water

Use with text pages 436 - 450

In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

1. The states in which water occurs on Earth are __________.
   a. liquid and gaseous only          c. solid and gaseous only
   b. liquid and solid only           d. solid, liquid, and gaseous

2. The physical property of ice that allows aquatic organisms to survive over the winter is its __________.
   a. high melting point            c. low density
   b. low boiling point              d. high mass

3. The water molecule is __________.
   a. polar and has polar bonds       c. nonpolar and has polar bonds
   b. polar and has nonpolar bonds    d. nonpolar and has nonpolar bonds

4. In comparison with covalent bonds, hydrogen bonds are __________.
   a. much stronger                   c. only slightly stronger
   b. of about the same strength      d. much weaker

5. A compound besides water that would be expected to form hydrogen bonds is __________.
   a. CH₃CH₂CH₂CH₃                    c. CH₂=CHCH₃
   b. CH₃CHOHCH₂CH₃                   d. CCl₄

6. During cooling from 50°C to 0°C, the density of water __________.
   a. first increases, then decreases   c. increases
   b. first decreases, then increases  d. decreases

7. The skinlike quality of the surface of water is caused by water’s __________.
   a. density                         c. covalent bonding
   b. boiling point                   d. surface tension

8. Compared to its height in a wide-diameter tube, the height of a column of water in a narrow-diameter tube will be __________.
   a. greater                           c. the same
   b. less                                d. unpredictable
9. Compared to the specific heat of most other materials, the specific heat of water is _________.
   a. about the same  c. much higher
   b. much lower  d. higher than some, lower than others

10. Which of the following processes is endothermic?
   a. cooling  c. freezing
   b. vaporization  d. condensation

11. Water seldom appears in a pure state on Earth because it tends to _________.
   a. evaporate  c. dissolve other substances
   b. change state so easily  d. react with other substances

Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

12. Most of the physical properties of water are similar to the properties of other molecules of about the same size.

13. The water molecule has two pairs of unbonded electrons.

14. Water has its maximum density at a temperature of about 0°C.

15. If lakes were made of ethanol rather than water, they would freeze from the bottom up.

16. The hydrogen end of a water molecule tends to have a partial negative change.

17. The force of attraction between two different molecules is known as an intermolecular force.

18. One would expect the hydrogen bonds in ethanol to be stronger than those in water.

19. The hydrogen bonds in a protein molecule will break more easily than the covalent bonds in the molecule.

20. The tendency to form liquid drops is less in water than it is in ethanol.

21. The stronger the hydrogen bonds in a liquid, the more curved will be its meniscus in a capillary tube.

22. The amount of heat needed to raise the temperature of 1 g of iron by 1°C is greater than the amount of heat needed to raise the temperature of 1 g of water by the same amount.

23. Substances made of nonpolar molecules are likely to dissolve in water.
Write the word or phrase that best completes each of the following sentences.

1. When a crystal of sodium chloride is dissolved in water, the oxygen ends of the water molecules are attracted to the __________ of the sodium chloride.

2. The usual method for representing a chloride ion in water solution is as __________.

3. Sugar can be dissolved in water because of the presence of bonds between __________ in its molecules.

4. An equation that represents the dissolving of sucrose (sugar) in water is __________.

5. Because sugar does not conduct an electric current in water solution, it is described as a(n) __________.

6. In general, nonpolar substances do not dissolve in water, but they do dissolve in __________.

7. __________ refers to the relative amount of solute dissolved in a solvent.

8. If the maximum amount of a compound that can dissolve in 100 mL of water is 22 g, then a solution of 20 g of that substance in 100 mL of water is said to be __________.

9. A solution of 25 g of the substance described in question 8 in 100 mL of water would be called __________.

10. In most cases, one way to increase the solubility of a solid substance in water is to increase the __________ of the solution.

11. A more precise way for describing the concentration of a solution than to describe it as concentrated or dilute is to state its __________.

12. To make 5 L of 1M aluminum nitrate (Al(NO₃)₃), you would have to dissolve __________ of the solute in 5.0 L of solution.

13. 400 mL of a 0.1M barium nitrate (Ba(NO₃)₂) solution consists of __________ of solute dissolved in 400 mL of solution.
14. One mole of the compound aluminum nitrate lowers the freezing point of a solution by \[\text{times}\] as much as one mole of sucrose.

15. Osmosis is the process by which molecules move through a \[\text{membrane}\].

16. The major difference between a solution and a colloid is \[\text{size}\] of particles.

**Explain how the two terms in each of the following pairs differ from each other.**

17. \[C_6H_{12}O_6(s)\] and \[C_6H_{12}O_6(aq)\] 

18. concentrated and dilute 

19. saturated and unsaturated 

20. endothermic and exothermic 

21. molarity and moles per liter of solvent 

22. value of freezing point of water and value of freezing point of an aqueous solution 

23. freezing point of 1M \(\text{NaCl}\) and freezing point of 1M \(\text{C}_6\text{H}_{12}\text{O}_6\) 

24. solute and solvent 

25. osmosis and reverse osmosis 

26. colloid and solution
For each item in Column A, write the letter of the best matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. H₃PO₄</td>
<td>a. property of acid</td>
</tr>
<tr>
<td>2. indicator</td>
<td>b. property of base</td>
</tr>
<tr>
<td>3. H₃O⁺</td>
<td>c. litmus</td>
</tr>
<tr>
<td>4. NH₃</td>
<td>d. #1 industrial chemical</td>
</tr>
<tr>
<td>5. Na₂O</td>
<td>e. polyprotic acid</td>
</tr>
<tr>
<td>6. sour taste</td>
<td>f. strong base</td>
</tr>
<tr>
<td>7. slippery feel</td>
<td>g. weak base</td>
</tr>
<tr>
<td>8. NaOH</td>
<td>h. weak acid</td>
</tr>
<tr>
<td>9. one acidic hydrogen</td>
<td>i. acidic anhydride</td>
</tr>
<tr>
<td>10. HC₂H₃O₂</td>
<td>j. basic anhydride</td>
</tr>
<tr>
<td>11. H₂SO₄</td>
<td>k. HC₂H₃O₂</td>
</tr>
<tr>
<td>12. SO₃</td>
<td>l. hydronium ion</td>
</tr>
</tbody>
</table>

Use each of the terms just once to complete the following paragraph.

acid base litmus acid anhydride basic anhydride H₃O⁺
adacidic hydrogen carbonates OH⁻

One way of detecting the presence of a(n) (13) _____________________ is by its bitter taste. This compound can also be recognized because it changes the color of (14) ___________________ from pink to blue. When placed in water, this type of compound releases (15) ___________________. Calcium hydroxide, a familiar example of this kind of compound, can be formed by adding calcium oxide to water, which makes calcium oxide a(n) (16) ___________________. In comparison, the addition of dinitrogen pentoxide (N₂O₅) to water results in the formation of HNO₃, a(n) (17) ___________________. In this case, dinitrogen pentoxide is called a(n)
(18) ________________. When HNO₃ is present in a water solution, it releases
a(n) (19) ________________ that combines with water to form a(n)
(20) ________________. A typical reaction for HNO₃ involves the release of
carbon dioxide gas from (21) ________________ or the release of hydrogen
from (22) ________________.

Write a chemical equation that illustrates each of the following points.

23. HBr is an acid. ________________

24. Boron hydride (BH₃) is a base. ________________

25. Any acid will react with calcium metal. ________________

26. Any ionic base dissociates in water. ________________

27. Any metal oxide (MO) is a basic anhydride. ________________

28. Rain is naturally acidic. ________________

Place a T for true or an F for false on the blank for each of the following state-
ments. Change the underlined word or phrase in each false statement to make it
true. Write your correction on the blank.

_______________ 29. Drain and oven cleaners work because they are acids.
_______________ 30. Litmus is red in acidic solution.
_______________ 31. Acids react with metals that are more active than hydrogen to
form a compound of the metal and hydrogen gas.
_______________ 32. NaOH is a base because it produces hydronium ions when it dis-
solves in water.
_______________ 33. Aqueous solutions of bases conduct electricity because a base in
water produces ions.
14.2 Strengths of Acids and Bases

In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

1. A strong acid, compared to a weak acid, __________.
   a. has a stronger taste   c. ionizes completely
   b. contains only acidic hydrogens   d. contains only two elements

2. The only weak acid listed below is __________.
   a. HCl   c. H2SO4
   b. HClO4   d. H2S

3. The only weak base listed below is __________.
   a. NaOH   c. Ba(OH)2
   b. HgOH   d. Sr(OH)2

4. The fraction of acetic acid molecules ionized in solution is about __________.
   a. 1%   c. 50%
   b. 25%   d. 100%

5. The acid most commonly found in soft drinks is __________.
   a. hydrochloric acid   c. carbonic acid
   b. carbolic acid   d. sulfuric acid

6. The acids and bases found in DNA and proteins are __________.
   a. weak acids and weak bases   c. strong acids and weak bases
   b. weak acids and strong bases   d. strong acids and strong bases

7. The pH of pure water is __________.
   a. 0   c. 7
   b. 1   d. 14

8. The pH most likely to be measured for a strong base is __________.
   a. 0   c. 8
   b. 5   d. 13

9. When hydrochloric acid is added drop-by-drop to a solution of sodium hydroxide, the pH of the mixture __________.
   a. stays the same   c. increases
   b. decreases   d. changes in an irregular way
10. A water solution of a strong acid is ________.
   a. always concentrated  
   b. never concentrated  
   c. sometimes concentrated, sometimes not  
   d. always dilute

11. In going from pH 4 to pH 5, the concentration of hydrogen ions ________.
   a. increases by a factor of 10  
   b. decreases by a factor of 10  
   c. doubles  
   d. is cut in half

12. All acid-base indicators ________.
   a. change color at different pH values  
   b. have more than one endpoint  
   c. change from pink to blue or blue to pink  
   d. are made from natural products

In the space provided, explain how the meanings of the two terms in each pair differ from each other. For some terms, there may be no difference.

13. pH and hydrogen ion concentration

14. Strong acid and weak acid

15. Hydronium ion and hydrogen ion

16. Sodium hydroxide and aluminum hydroxide

17. pH = 5 and pH = 9

18. Litmus and acid/base indicator

19. pH = 7 and neutral solution

20. pH meter and indicator paper

21. Concentration and strength

22. pH of milk and pH of vinegar
15.1 Acid and Base Reactions

From the following list of terms, select the one that best completes each statement. Use each term only once.

<table>
<thead>
<tr>
<th>acid-base indicator</th>
<th>base</th>
<th>salt</th>
<th>NH₄⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCN</td>
<td>H₂O</td>
<td>neutralization reaction</td>
<td></td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>Na⁺</td>
<td>H₃O⁺</td>
<td></td>
</tr>
</tbody>
</table>

1. BaCl₂, Mg(NO₃)₂, and Na₂SO₄ are all examples of a(n) ________________.
2. Litmus paper is an example of a(n) ________________.
3. Because it breaks down completely into positive and negative ions in solution, ________________ is considered a strong acid.
4. Because it is usually a spectator ion, the chemical symbol ________________ seldom appears in net ionic equations.
5. Because it does not noticeably dissociate or ionize, the formula ________________ often appears in net ionic equations.
6. Because it represents a weak acid, the chemical formula ________________ would be expected to appear in a net ionic equation.
7. When ammonia occurs in water solution, it forms the ion ________________.
8. A substance that accepts hydrogen ions is a(n) ________________.
9. The addition of an acid to water can be considered an acid-base reaction because water molecules accept hydrogen ions to become ________________ ions.
10. By adding an acid to a base, you can observe a(n) ________________.

Answer each of the following questions.

11. Does the reaction between equal amounts of an acid and a base always produce a neutral solution? Why or why not? ________________

12. What color would you expect to see in a piece of litmus paper to which the following have been added?
   a. 1 drop of Ca(OH)₂ ________________
   b. 1 drop of HI ________________
   c. 1 drop of KNO₃ ________________
13. What would the pH be of a solution formed by mixing the following?
   a. equivalent amounts of KOH and H₂SO₄
   b. equivalent amounts of KOH and HCN
   c. equivalent amounts of NH₃ and H₂SO₄

Write the overall, ionic, and net ionic equations for each of the following reactions.


15. Reaction B: perchloric acid plus aluminum hydroxide yields water plus aluminum perchlorate

16. Reaction C: hydrocyanic acid (HCN) plus calcium hydroxide yields calcium cyanide plus water

For each of the above reactions, tell whether you would expect the pH of the final solution to be: a: 7.0; b: greater than 7.0; c: less than 7.0.

17. Reaction A
18. Reaction B
19. Reaction C
Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

1. The normal pH of blood is about 2.5. [T]
2. A buffer is a solution that resists changes in pH when moderate amounts of acid and base are added. [F]
3. The amount of carbon dioxide in the blood buffer system is controlled by the lungs. [F]
4. The natural buffering that occurs in some lakes is a result of carbon dioxide in the air. [T]
5. The normal pH of stomach acid is about 6.5. [F]
6. Antacids are generally hydroxides or carbonates. [T]
7. In doing a titration, both of the solutions used must be a standard solution. [F]
8. To improve the results obtained in a titration, you should always repeat that titration several times. [T]
9. In most acid-base reactions, the oxidation numbers of the elements involved do change. [F]

Complete each of the following statements.

10. The other half of a buffer system containing sodium citrate would be __________________. [HCl]
11. When hydroxide ions are added to blood, they react with __________________ in the carbon dioxide buffer system. [H2CO3]
12. Yawning is a mechanism by which the body gets rid of excess __________________. [CO2]
13. The pH of an acidic lake would be less than _________________. [5.5]
14. The two most common bases used in antacids are __________________________. [Al(OH)3, Mg(OH)2]
15. The long calibrated tube used in titrations is called a(n) _________________. [ burette]
The dissolved carbon dioxide blood buffer system maintains quite a constant pH in blood. Write the word or phrase that best completes each statement about this system.

16. The CO₂ dissolves in water to produce ________________.

17. The other part of the buffer system is the ________________ ion.

18. If OH⁻ ions increase in the blood, ________________ reacts to lower its concentration.

A buffer system used by the body to control large changes in pH is the phosphate system. The system consists of the hydrogen phosphate (HPO₄²⁻) and dihydrogen phosphate (H₂PO₄⁻) ions of the triprotic (three-proton) acid H₃PO₄.

19. Write an ionic equation that shows how the hydrogen phosphate ion reacts with a water molecule.

20. Write a net ionic equation that shows what happens when a hydrogen ion is added to the products of the reaction in question 19.

21. Write a net ionic equation that shows how a hydroxide ion reacts with a dihydrogen phosphate ion.

Answer each of the following questions about titration reactions.

22. In a titration, 50 mL of 0.2M sodium hydroxide reacts exactly with 250 mL of hydrochloric acid. What is the molarity of the hydrochloric acid?

23. In a titration between 0.1M hydrochloric acid and a base of unknown strength, 40 mL of the acid were required to neutralize exactly 8 mL of the base. What is the molarity of the base?

24. 23.8 mL of a sulfuric acid solution is required to neutralize 34.2 mL of a 0.2M potassium hydroxide solution. What is the molarity of the sulfuric acid solution?

25. How many milliliters of 2M sodium hydroxide are needed to neutralize 15 mL of 0.6M hydrochloric acid?
16.1 The Nature of Oxidation-Reduction Reactions

Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

1. Every oxidation reaction is accompanied by a reduction reaction.  

2. A compound formed between oxygen and one other element is called an acid.  

3. Oxidation is any reaction in which one element or compound loses electrons to a more electronegative element.  

4. One way to protect iron from rusting is to cover it with a less active metal, such as zinc.  

5. Another name for an oxidation-reduction reaction is a synthesis reaction.  

6. The oxidation number of any free element is 1+.  

7. When an element is oxidized, its oxidation number increases.  

8. Redox half-reactions seldom occur alone.  

9. A net oxidation-reduction reaction is the sum of the oxidation half-reaction plus the reduction half-reaction.  

10. During a redox reaction, an oxidizing agent is always reduced.  

11. Oxygen must be present for a redox reaction to occur.  

12. During a redox reaction, a reducing agent loses oxygen.
For each of the following reactions, on the space provided, identify the element that is oxidized (O), the element that is reduced (R), the oxidizing agent (OA), and the reducing agent (RA).

13. \(2H_2(g) + O_2(g) \rightarrow 2H_2O(l)\)
   - O ____  R ____  OA ____  RA ____

14. \(Mg(s) + I_2(s) \rightarrow MgI_2(s)\)
   - O ____  R ____  OA ____  RA ____

15. \(2Ag^+ (aq) + Cu(s) \rightarrow Cu^{2+} (aq) + 2Ag\)
   - O ____  R ____  OA ____  RA ____

16. \(I_2O_3(s) + CO(g) \rightarrow I_2(s) + CO_2(g)\)
   - O ____  R ____  OA ____  RA ____

17. \(10Cl_2^- (aq) + 2MnO_4^- (aq) + 16H^+ (aq) \rightarrow 5Cl_2(g) + 2Mn^{2+} (aq) + 8H_2O(l)\)
   - O ____  R ____  OA ____  RA ____

Answer the following questions.

18. What electron change takes place in the following reaction? \(Fe(s) + Cu^{2+} (aq) \rightarrow Cu(s) + Fe^{3+} (aq)\) ________________

19. What general rule can you state about the exchange of electrons between the oxidizing agent and the reducing agent in a redox reaction? ________________

20. What is the total number of electrons exchanged in the following redox reaction?
   \(2Cr^{3+} (aq) + 3Sn^{4+} (aq) \rightarrow 2Cr^{6+} (aq) + 3Sn^{2+} (aq)\) ________________

21. Write the oxidation half-reaction and the reduction half-reaction for the following redox reaction. \(2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)\) ________________

22. What is the oxidizing agent and the reducing agent in the following reaction?
   \(3NO_2(g) + H_2O \rightarrow 2HNO_3(aq) + NO(g)\) ________________
16.2 Applications of Oxidation-Reduction Reactions

In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

1. In modern photographic film, the substance that is oxidized is ________.
   a. Ag⁺  
   b. Ag⁰  
   c. Br⁻  
   d. Br⁰

2. The reaction above takes place because of the presence of ________.
   a. Ag⁺  
   b. Br⁻  
   c. O₂  
   d. light

3. The presence of dark spots on an exposed film is caused by ________.
   a. silver ions  
   b. silver atoms  
   c. bromide ions  
   d. bromine atoms

4. The fixer used in developing films reacts chemically with ________.
   a. thiosulfate ions  
   b. hydroquinone  
   c. silver ions  
   d. silver atoms

5. The three substances added to the top of a blast furnace are iron ore, limestone, and ________.
   a. carbon monoxide  
   b. carbon dioxide  
   c. oxygen  
   d. coke

6. The oxidizing agent in a blast furnace is ________.
   a. Fe³⁺  
   b. CaO  
   c. O²⁻  
   d. CO

7. The oxidation number of chlorine in the hypochlorite ion (OCl⁻) is ________.
   a. 1⁻  
   b. 1⁺  
   c. 2⁻  
   d. 0

8. The green color of the Statue of Liberty is caused by ________.
   a. copper metal  
   b. copper compounds  
   c. iron metal  
   d. iron compounds

9. An aluminum can is protected from corrosion by a thin layer of ________.
   a. zinc  
   b. steel  
   c. aluminum metal  
   d. aluminum oxide
10. The tarnish that forms on silver utensils is caused by ________.
   a. oxygen  c. hydrogen sulfide
   b. moisture in the air  d. contact with another metal

11. A compound that emits “cool light” when oxidized is ________.
   a. hydroquinone  c. luminol
   b. nitrogen in the atmosphere  d. Fe₂O₃

12. An antioxidant that will prevent an apple from turning brown after being cut is ________.
   a. vitamin C  c. H₂O₂
   b. oxygen  d. aluminum foil

Write an oxidation half-reaction for each of the following examples of redox reactions.

13. Photography ________________________________

14. Blast furnace for making iron ________________________________

15. Bleaching ________________________________

16. Statue of Liberty ________________________________

17. Self-protecting aluminum coating ________________________________

18. Tarnishing of silver ________________________________

Answer the following questions.

19. When chlorine gas is used as a disinfectant, it oxidizes vital molecules in bacteria. Write a redox half-reaction that shows what happens to the chlorine in this reaction. ________________________________

20. What is an “activated” grain of silver bromide in an exposed photographic film? ________________________________

21. What color would the Statue of Liberty be if it were made of sheets of silver rather than sheets of copper? ________________________________

22. How does the negative for an exposed film get its name? ________________________________
Place a T for true or an F for false in front of each of the following statements. Then, for those statements that are false, change the underlined word or words to make the statement true.

1. The first practical battery was constructed by Galvani.  
2. Electrolysis is a process by which an electrical current causes a spontaneous redox reaction to occur.  
3. During electrolysis, electrons flow into a cell through the cathode.  
4. In a Downs cell, sodium metal forms at the carbon anode.  
5. The ion HCO₃⁻ is an example of an anion.  
6. Charge is conducted through an electrolytic cell by means of the anode.  
7. The purpose of a battery in an electrolysis system is to pump electrons through the system.  
8. Every electrolytic cell must produce at least one half-reaction(s).  
9. The purpose of using hydroelectric power for commercial electrolysis operations is to ensure a sufficient supply of water for the operations.  
10. The substance from which aluminum is obtained in the Hall-Héroult process is aluminum oxide, Al₂O₃.  
11. During the electroplating of an object, the object is used as the anode in an electrolytic cell.  
12. An electrochemical procedure for identifying large biological molecules is electrophoresis.

Answer the following questions.

13. Why do oxidation and reduction always occur together? __________________________  
14. Is it possible to have an electrical current that consists of something other than electrons? __________________________
15. Since sodium chloride already exists in the form of ions, why is it necessary to melt the compound before decomposing it in a Downs cell? ______________

16. When an aqueous solution of sodium chloride is electrolyzed, hydrogen gas is produced at the cathode. When an aqueous solution of copper(II) chloride is electrolyzed, copper is produced at the cathode. How do you explain this difference? ______________

17. Why are the electrodes used in electrolytic processes such as in the Downs cell and in the Hall-Héroult process always made of inert substances, such as graphite or platinum? ______________

In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

18. The first person to observe the flow of electricity between two dissimilar metals was _________.

19. The part of an electrolytic cell at which reduction occurs is the _________.
   a. anode  b. cathode  c. battery  d. electrolyte

20. If 500 electrons per second are being released at one electrode of an electrolytic cell, then the number of electrons per second being used up at the other electrode is _________.
   a. at least 500  b. exactly 500  c. greater than 500  d. dependent on the chemicals used

21. The product that can be obtained by the electrolysis of molten sodium chloride but not of aqueous sodium chloride is _________.
   a. hydrogen gas  b. chlorine gas  c. metallic sodium  d. oxygen gas
Write the word or phrase that best completes each of the following sentences.

1. In a lemon battery, current is conducted through the lemon by means of ________________.

2. The reaction that takes place at the anode of the lemon battery for any metal, M, is ________________.

3. The term ________________ is used to describe the difference in electrical “pressure” between any two electrodes in a galvanic cell.

4. Unlike galvanic cells, electrolytic cells have a(n) ________________.

5. In a galvanic cell, electrical energy comes from ________________.

6. Of the two metals, zinc and lead, ________________ is more easily oxidized.

7. A half-reaction in which silver ions are reduced is ________________.

8. If silver were used as an electrode in a galvanic cell in which the half-reaction in question 7 takes place, it would be the ________________ of that cell.

9. In a galvanic cell consisting of a strip of copper, a strip of iron, electrolytes, and a salt bridge, the only way to increase the total amount of energy produced by the cell is ________________.

10. One way to increase the potential difference in the galvanic cell in question 9 is to ________________.

11. A dry cell is not really dry because the electrolyte it contains is in the form of a(n) ________________.
12. In a dry cell, the zinc casing acts as the ________________ of the cell.

13. The two electrodes in a lead storage battery are made of ________________ and ________________.

14. The product formed in a lead storage battery as the battery discharges is ________________.

In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

15. If aluminum and iron are both present in a galvanic cell, the reaction most likely to take place is __________.
   a. Al → Al$^{3+}$ + 3e$^{-}$
   b. Fe → Fe$^{2+}$ + 2e$^{-}$
   c. Al$^{3+}$ + 3e$^{-}$ → Al
   d. Fe$^{2+}$ → Fe$^{3+}$ + e$^{-}$

16. A galvanic cell that can be transported somewhat easily is known as a(n) __________.
   a. voltaic cell
   b. electrolytic cell
   c. battery
   d. fuel cell

17. The type of chemical reaction that always takes place within a galvanic cell is __________.
   a. synthesis
   b. single displacement
   c. double displacement
   d. redox

18. The amount of energy available from a galvanic cell with electrodes made of metals A and B depends on __________.
   a. the amount of A and B available
   b. the potential difference between electrodes A and B
   c. neither of these factors
   d. both of these factors

19. The fewest number of galvanic cells a battery can contain is __________.
   a. one
   b. two
   c. six
   d. twelve
For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. alkane</td>
<td>a. process that separates petroleum into many hydrocarbons</td>
</tr>
<tr>
<td>2. alkene</td>
<td>b. process that converts large alkanes to aromatic hydrocarbons</td>
</tr>
<tr>
<td>3. alkyne</td>
<td>c. ( \text{CH}_3\text{—CH=CH}_2 ), ( \text{CH}≡\text{CH} ), or ( \text{CH}_3\text{—CH}_2\text{—CH=CH}_2 )</td>
</tr>
<tr>
<td>4. aromatic hydrocarbon</td>
<td>d. compounds with the same formula but different structures</td>
</tr>
<tr>
<td>5. cracking</td>
<td>e. benzene</td>
</tr>
<tr>
<td>6. fractional distillation</td>
<td>f. decane</td>
</tr>
<tr>
<td>7. isomer</td>
<td>g. ( \text{CH}_3\text{—CH≡CH—CH}_3 )</td>
</tr>
<tr>
<td>8. reforming</td>
<td>h. process that converts large alkanes to small alkanes and alkenes</td>
</tr>
<tr>
<td>9. unsaturated hydrocarbon</td>
<td>i. ( \text{CH}_3\text{—CH}_2\text{—CH}_2\text{—C≡C—CH}_3 )</td>
</tr>
</tbody>
</table>

Compare the hydrocarbons in the following pairs. Explain how they differ or state the relationship between the hydrocarbons.

10. alkanes and alkenes __________________________________________________________________________

11. alkenes and alkynes __________________________________________________________________________

12. straight and branched chains __________________________________________________________________

13. aromatic and alkane ring compounds __________________________________________________________________

14. petroleum and gasoline ________________________________________________________________________
15. propane and hexane

16. cyclohexane and benzene

17. 1-butene and 2-butene

18. trans-2-butene and cis-2-butene

19. 2-methylpentane and 3-methylpentane

20. cyclopentane and cyclohexane

21. methane and methyl

22. saturated and unsaturated

23. 2,2-dimethylpentane and 2,3-dimethylpentane

24. benzene and naphthalene
For each functional group in Column A, write the letter of the correct organic family in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>________</td>
<td>1. —C≡C—</td>
</tr>
<tr>
<td>________</td>
<td>2. —C≡C—</td>
</tr>
<tr>
<td>________</td>
<td>3. —C—OH</td>
</tr>
<tr>
<td>________</td>
<td>4. —C—Cl</td>
</tr>
<tr>
<td></td>
<td>O</td>
</tr>
<tr>
<td>________</td>
<td>5. —C—OH</td>
</tr>
<tr>
<td></td>
<td>O</td>
</tr>
<tr>
<td>________</td>
<td>6. R—C—O—R'</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>________</td>
<td>7. R—C—R'</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>________</td>
<td>8. R—C—H</td>
</tr>
<tr>
<td>________</td>
<td>9. R—O—R'</td>
</tr>
<tr>
<td>________</td>
<td>10. R—NH₂</td>
</tr>
<tr>
<td></td>
<td>O</td>
</tr>
<tr>
<td>________</td>
<td>11. R—C—NH₂</td>
</tr>
</tbody>
</table>

In the space at the left, write the letter of the class of compounds that best fits the property listed.

| ________ | 12. Are found in proteins |
|          | a. esters |
|          | b. ethers |
|          | c. aldehydes |
|          | d. amides |

| ________ | 13. Have a tart taste, often with a strong, unpleasant odor |
|          | a. aldehydes |
|          | b. ketones |
|          | c. carboxylic acids |
|          | d. esters |
14. Have a strong, often pleasant aroma; are used in the manufacture of perfumes
   a. esters   c. amines
   b. ethers   d. amides

15. Are used in the production of CFCs, DDT, PCBs, and PVC
   a. alkenes   c. alcohols
   b. halogenated hydrocarbons   d. aldehydes

16. Are polar, have high boiling points, and are water soluble if of low molecular mass
   a. amides   c. alcohols
   b. alkynes   d. ethers

17. Were once used as anesthetics, but no longer used for that purpose today
   a. esters   c. amines
   b. ethers   d. amides

18. Include cinnamon, vanilla, almond, and other flavorings.
   a. halogenated hydrocarbons   c. ketones
   b. alcohols   d. aldehydes

From the following list of substituted hydrocarbons, select the one that best fits each of the applications below.

a. alcohol  d. alkene  g. amine  j. ether
b. aldehyde  e. alkyne  h. carboxylic acid  k. ketone
c. alkane  f. amide  i. ester  l. halogenated hydrocarbon

19. refrigerant in air conditioning unit
20. vinegar
21. solvent for fats and waxes
22. natural gas
23. cooking oil
24. acetylene torch
25. beer and wine
26. nail polish remover
27. ethylene fruit-ripenener
28. formaldehyde preservative
Use each of the terms below just once to complete the passage.

addition reaction  
condensation  
monomer  
polymer  
cross-linking  
thermoplastic  
thermosetting

Polyethylene is a synthetic material used for many different purposes, including the manufacturing of milk jugs and plastic beakers. The repeating unit, called a (1) ________________ , which forms polyethylene, is ethylene. Many hundreds or thousands of ethylene molecules combine in a reaction known as a(n) (2) ________________ , in which double bonds are broken when the repeating units combine. Because it is made of so many repeating units, polyethylene is an example of a(n) (3) ________________ . In polyethylene, the molecules are arranged in a long, linear sequence. Such materials are usually (4) ________________ , meaning that they tend to melt or soften when heated. Other polymers do not melt when heated and are called, therefore, (5) ________________ plastics. One reason that some polymers tend not to melt when heated is that their molecules undergo (6) ________________ , which tends to make the material more rigid. Other polymers are formed in a chemical reaction known as (7) ________________ during which a small molecule such as water is eliminated during the reaction.

Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

8. Every polymer includes repeating units called monomers.  
8. Monomers are a subset of polymers.  

9. Teflon is a naturally-occurring polymer of tetrafluoroethylene.  
9. Teflon is a synthetic polymer of tetrafluoroethylene.  

10. The properties of a polymer are exactly like those of the monomer of which it is formed.  
10. The properties of a polymer are different from those of the monomer of which it is formed.  

11. DNA, protein, and silk are examples of naturally-occurring polymers.  
11. DNA, protein, and silk are examples of synthetic polymers.
12. Cellulose and starch are made of the same monomer.

13. Addition reactions cannot occur between double-bonded molecules.

14. During vulcanization, sulfur is added to liquid latex to make a more flexible product.

15. Polyethylene is an example of a thermoplastic polymer.

In each of the following statements, select the letter of the word or phrase that best completes the sentence.

16. A polymer that was discovered accidentally is __________.
   a. nylon
   b. polyethylene
   c. Teflon
   d. rubber

17. An example of a naturally occurring polymer is __________.
   a. polyethylene
   b. cellulose
   c. Teflon
   d. nylon

18. The monomer from which cellulose and starch is made is __________.
   a. glucose
   b. ribose
   c. cyclohexane
   d. benzene

19. Whether a monomer will undergo addition polymerization or condensation polymerization depends on __________.
   a. the size of the molecule
   b. the molecule’s structure
   c. whether the molecule is aromatic
   d. whether the molecule occurs naturally or not

20. When two polymer chains link to each other, the process is known as __________.
   a. addition
   b. condensation
   c. cross-linking
   d. chain-linking
In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

1. The monomers from which proteins are made are ________.
   a. simple sugars  c. nitrogen bases
   b. amino acids  d. fatty acids

2. ________ generally are proteins.
   a. Cellulose  c. Lipids
   b. Amino acids  d. Enzymes

3. The linkage of atoms that joins the monomers in a protein molecule is known as a(n) ________.
   a. peptide bond  c. disulfide bond
   b. active site  d. hydrogen bond

4. The point at which an enzyme bonds to a substrate is known as the ________.
   a. peptide bond  c. binding site
   b. active site  d. substrate groove

5. Which of the following is a disaccharide?
   a. glucose  c. ribose
   b. fructose  d. sucrose

6. The organic family to which glycerol belongs is the ________.
   a. alcohols  c. carboxylic acids
   b. alkanes  d. simple sugars

7. A polyunsaturated fatty acid molecule contains ________.
   a. one double bond  c. more than one double bond
   b. one triple bond  d. both double and triple bonds

8. One important way lipids are used in the body is ________.
   a. to make proteins  c. to digest fats
   b. as a source of energy  d. as enzymes

9. A nucleotide consists of a simple sugar, a phosphate group, and ________.
   a. a fatty acid  c. glycerol
   b. a disaccharide  d. a nitrogen base
10. The nitrogen base found in DNA but not in RNA is _________.
   a. adenine  c. guanine
   b. cytosine  d. thymine

From the following list of biochemical families, select the one that best fits each of the words, phrases or formulas below.

C: Carbohydrates  L: Lipids
P: Proteins  N: Nucleic Acids

11. genetic information
12. chitin
13. -sugar-phosphate-sugar-phosphate-etc.
14. insulin
15. CH₃CH₂CH₂CH₂CH₂CH₂CH₂CH₂CH₂CH₂CH₂CH₂COOH
16. lactose and maltose
17. cholesterol
18. hemoglobin
19. long-term energy storage
20. \[ \begin{array}{c}
   \text{H} \\
   \text{C} \quad \text{COOH} \\
   \text{NH}_2
\end{array} \]

Answer the following questions.

21. Is an amino acid strongly acidic or basic? How do you know? _____________________________
______________________________

22. Maltose is a disaccharide, but when it breaks down it forms only glucose.
   Explain how this is possible. _____________________________
______________________________

23. One of the great prior discoveries on the basis of which Watson and Crick carried out their successful research was that the ratio of adenine to thymine in DNA is almost exactly one, as is the ratio of guanine to cytosine. Explain the significance of that fact. _____________________________
______________________________
Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

1. The processes by which carbohydrates, proteins, and lipids are digested are catalyzed by disaccharides.

2. The energy stored in the bonds of nutrient molecules was originally converted from light energy by means of respiration.

3. Insulin is an example of a hormone, a molecule that carries messages throughout the body.

4. Most of the energy used by cells comes from the oxidation of proteins.

5. Chemical reactions that take place in cells occur as rapidly as they do because of the presence of lipids in the cells.

6. From a chemical standpoint, respiration is the process by which glucose reacts with oxygen to form water and carbon dioxide.

7. When a phosphate group is added to ADP, energy is released.

8. In the final step of the electron transport chain, electrons are transferred to oxygen atoms.

9. Cells die when deprived of oxygen because they can no longer harness electrons.

10. The fatigue in an athlete’s muscles after exercising is caused by the presence of ethanol.

11. During glycolysis, 2 molecules of ATP are produced.

12. The total number of ATP molecules produced during the breakdown of glucose is 36.

Provide the missing part of each of the following chemical equations, and tell what function the reaction has in the body.

13. glucose + oxygen → 


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14. \[ \text{substrate} \rightarrow \text{ATP} \]

15. \[ \text{NAD}^+ + \text{e}^- \rightarrow \text{product} \]

16. \[ \text{three-carbon compound} + \text{yeast} \rightarrow \text{product} + \text{carbon dioxide} \]

**Answer the following questions.**

17. Name the types of organic compounds you would expect to find in the bloodstream.

18. Explain whether it is correct to say that the term metabolism refers to the chemical reactions by which biomolecules are broken down to produce energy.

19. What is the connection between breathing and respiration?

20. Where does the oxygen come from to make the water that is the final product of respiration? Where does the hydrogen come from?

21. What is the function of alcoholic fermentation in the baking industry?
Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

1. Heat is released in an exothermic reaction.

2. Combustion is a familiar example of a(n) endothermic reaction.

3. The unit used to measure energy in the SI system is the Calorie.

4. According to the law of conservation of energy, energy cannot be changed from one form to another during a chemical reaction.

5. The value of \( \Delta H \) for exothermic reactions is always negative.

6. Energy is conserved only in exothermic reactions.

7. Activation energy is generally required to initiate endothermic, but not exothermic reactions.

8. In an exothermic reaction, the energy of the products is less than the energy of the reactants.

9. The use of a catalyst increases the amount of product formed.

10. An increase in entropy corresponds to a(n) increase in disorder.

11. Exothermic reactions are usually spontaneous.

12. The total amount of entropy in the universe has a tendency to stay the same.
13. In a spontaneous reaction, entropy can decrease.

14. An endothermic reaction requires a continuous input of energy.

Answer the following questions.

15. Chemical systems move toward decreased energy. Does that mean that all chemical reactions are exothermic? Explain.

16. Why does steam have greater entropy than liquid water?

17. Which has greater entropy, a tablespoon of dry salt or a tablespoon of salt dissolved in water? Explain.

18. Assuming that temperature does not change, would there be an increase or decrease in entropy in the following reaction $\text{SO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{SO}_3(\text{aq})$? Explain.
For each term or symbol in Column A, write the letter of the matching definition in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ΔT</td>
<td>a. heat gained or lost by water</td>
</tr>
<tr>
<td>2. C_w</td>
<td>b. 1000 cal</td>
</tr>
<tr>
<td>3. q_w</td>
<td>c. 4.184 J</td>
</tr>
<tr>
<td>4. q_{reaction}</td>
<td>d. molar mass</td>
</tr>
<tr>
<td>5. 1 kJ</td>
<td>e. temperature change</td>
</tr>
<tr>
<td>6. 1 cal</td>
<td>f. Celsius temperature</td>
</tr>
<tr>
<td>7. 1 J</td>
<td>g. heat given off or absorbed in a chemical change</td>
</tr>
<tr>
<td>8. Cal</td>
<td>h. 0.239 cal</td>
</tr>
<tr>
<td>9. °C</td>
<td>i. specific heat of water</td>
</tr>
<tr>
<td>10. g/mol</td>
<td>j. 1000 joules</td>
</tr>
</tbody>
</table>

Solve the following problems.

11. A sample of butane (C_4H_{10}) gas is burned inside a calorimeter that contains 2.0 kg of water. The temperature of the water rises by 10.2°C. How much heat was produced in the reaction? __________________________________________________________________________

12. A 5.5-g sample of steel wool is ignited in a calorimeter containing 1.75 kg of water. The temperature of the water rises from 22.50°C to 29.30°C. What is the heat produced by this chemical change? __________________________________________________________________________

13. Convert each of the following measurements.
   a. 2.38 cal to J __________________________________________________________________________
   b. 3560 cal to kcal ________________________________________________________________________
   c. 165.9 kJ to Cal ________________________________________________________________________
   d. 8191 kJ to cal ________________________________________________________________________
14. The data below was obtained for a sample of peas burned in a calorimeter. Find the energy released, in both kilojoules per gram and Calories per gram.

| Mass | 2.75 grams |
| Mass of water in calorimeter | 1500 grams |
| Initial temperature (°C) | 20.00°C |
| Final temperature (°C) | 23.00°C |

Energy content (kJ/g; Cal/g) 

Answer the following questions.

15. What is a calorimeter? Explain how the device is used.

16. Explain the relationship between calories, Calories, and kilocalories.

17. What is efficiency? Explain why it is impossible for any energy-related process to be 100 percent efficient.
20.3 Photosynthesis

In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

1. Photosynthesis can take place in all of the following kinds of organisms except ________.
   a. plants
   b. animals
   c. algae
   d. bacteria

2. Photosynthesis uses carbon dioxide, water, and ________.
   a. glucose
   b. carbohydrates
   c. oxygen
   d. light

3. The color absorbed least by the chlorophyll molecule is ________.
   a. red
   b. blue
   c. green
   d. violet

4. The chlorophyll in plants is found ________.
   a. in chloroplasts
   b. in cell membranes
   c. in cell nuclei
   d. throughout the cell

5. The light that strikes a chlorophyll molecule ________.
   a. changes ATP to ADP
   b. excites electrons
   c. changes NADP to NADPH
   d. splits a water molecule

6. When water is split apart in the early stages of photosynthesis, the products are ________.
   a. hydrogen gas and oxygen gas
   b. hydrogen and oxygen ions
   c. oxygen gas and hydrogen ions
   d. hydrogen gas and oxygen ions

7. Two molecules formed during photosynthesis that pass on to the Calvin cycle are ________.
   a. ADP and NADP
   b. ATP and NADP
   c. ADP and NADP
   d. ATP and NADPH

8. The oxygen used to produce glucose in the Calvin cycle comes primarily from ________.
   a. water
   b. carbon dioxide
   c. chlorophyll
   d. carbohydrates
In the space provided, explain how the two terms in the following pairs differ from each other or are related to each other.

9. photosynthesis and respiration  
   
10. chlorophyll and chloroplasts  
   
11. glucose and carbohydrate  
   
12. light reactions and Calvin cycle  
   
Answer the following questions.

13. A classical question in the study of photosynthesis was whether the oxygen released during the process comes from carbon dioxide or water. What is now known to be the correct answer to that question?  
   
14. Microorganisms known as purple bacteria capture solar energy by means of a process similar to photosynthesis, but they use hydrogen sulfide (H₂S) instead of water. What would be the products of this process?  

21.1 Types of Radioactivity

For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. $^4_2$He</td>
<td>a. gamma ray</td>
</tr>
<tr>
<td>2. $^0_2$e</td>
<td>b. coined the term radioactivity</td>
</tr>
<tr>
<td>3. $\gamma$</td>
<td>c. process in which atomic number decreases by 2</td>
</tr>
<tr>
<td>4. Becquerel</td>
<td>d. $^{238}<em>{92}$U $\rightarrow ^{9}</em>{2}$He + ?</td>
</tr>
<tr>
<td>5. Curie</td>
<td>e. ability to continue glowing after absorbing light</td>
</tr>
<tr>
<td>6. alpha decay</td>
<td>f. a flash of light</td>
</tr>
<tr>
<td>7. beta decay</td>
<td>g. is called an alpha particle</td>
</tr>
<tr>
<td>8. phosphorescence</td>
<td>h. is used to determine age of once-living materials</td>
</tr>
<tr>
<td>9. $^9_4$Be</td>
<td>i. discoverer of radioactivity</td>
</tr>
<tr>
<td>10. $^{234}_{90}$Th</td>
<td>j. contains four protons and five neutrons</td>
</tr>
<tr>
<td>11. scintillation</td>
<td>k. process in which atomic number increases by 1</td>
</tr>
<tr>
<td>12. $^{14}_6$C</td>
<td>l. is called a beta particle</td>
</tr>
</tbody>
</table>
Answer the following questions.

13. Contrast alpha decay, beta decay, and gamma decay in terms of what is released and the change in the atomic number and mass number of the nucleus.

14. Explain what a Geiger counter is used for and how it operates.

15. Explain what is meant by the half-life of a radioactive isotope.

Solve the following problems.

16. After 8.0 years, how much remains of a radioactive isotope whose half-life is 2.0 years if the original mass of the sample was 32 g?

17. How long will it take a 60.0 g-sample of a radioactive isotope with a half-life of $4.30 \times 10^6$ years to decay to 7.5 g?

18. A sample of a radioactive isotope with a mass of 64.0 g decays to 1.0 g in 18 minutes. What is the half-life of the isotope?

19. It has taken a radioactive isotope with a half-life of 3.24 years 16.2 years to reduce in mass to 2.5 g. What was the original mass of the isotope?
Place a T for true or an F for false on the blank for each of the following statements. Change the underlined word or phrase in each false statement to make it true. Write your correction on the blank.

1. The equivalence of mass and energy was discovered by Albert Einstein.
2. The first person to observe a nuclear fission reaction was Lise Meitner.
3. The subatomic particle that is necessary in order to initiate the nuclear fission of uranium-235 is a(n) alpha particle.
4. The subatomic particle that is produced during a nuclear chain reaction involving uranium-235 is a(n) neutron.
5. The most common isotope used in nuclear reactors today is uranium-238.
6. The purpose of the control rods in a nuclear reactor is to release neutrons produced during nuclear fission.
7. Steam produced in a nuclear reactor is used to drive a(n) steam reactor in a nuclear power plant.
8. Currently, the only element other than uranium that is used as a fuel in nuclear reactors is plutonium.
9. A deuterium atom differs from an atom of hydrogen-1 in the number of protons in its nucleus.
10. One type of fusion reactor currently being tested is called the tomahawk.

State the function of each of the following parts of a nuclear power plant.

11. Fuel rods

12. Control rods

13. Moderator
The illustration below shows two nuclear reactions that involve the same reactant. Answer the following questions about these reactions.

**Reaction A**

\[ + + \rightarrow + + \]

**Reaction B**

\[ + + \rightarrow + + + \]

17. What kind of nuclear reaction is illustrated in each reaction? ________________________

18. Write the symbol for the reactant, using the notation that shows the mass number and atomic number. What is the name of this isotope? ________________________

19. Write the symbols for the two products in Reaction A. What are the names of these particles? ________________________

20. Write the symbols for the two products in Reaction B. What are the names of these products? ________________________
In the space at the left, write the letter of the word or phrase that best completes the statement or answers the question.

1. When radiation is used to treat a disease, the radiation destroys __________ .
   a. only cancer cells  c. both cancer and healthy cells
   b. only healthy cells  d. only rapidly growing cells

2. When radioactive isotopes are used for diagnostic purposes, they are being used to __________ .
   a. treat a disease  c. learn more about a normal function
   b. identify a medical disorder  d. kill cancer cells

3. The correct nuclear symbol for a positron is __________ .
   a. $^+\text{e}_0$  c. $^0\text{e}_-1$
   b. $^1\text{e}_0$  d. $^1\text{e}_+1$

4. The letter m in the symbol for the radioactive isotope technetium-99m indicates that when a nucleus of this isotope decays, its atomic mass will __________ .
   a. decrease by four  c. decrease by two
   b. increase by two  d. stay essentially the same

5. Cancer cells are more likely to be killed by radiation than are healthy cells because the cancer cells __________ .
   a. are more numerous  c. divide more rapidly
   b. contain DNA  d. divide more slowly

6. The only kind of isotope listed below that could not be used as a tracer is __________ .
   a. an alpha emitter  c. a beta emitter
   b. a gamma emitter  d. a stable isotope

7. Radiation can be used to preserve foods because it destroys __________ .
   a. microorganisms  c. DNA in food cells
   b. toxic chemicals  d. decayed food cells

8. A device in which artificial elements can be made is a(n) __________ .
   a. PET machine  c. cyclotron
   b. Geiger counter  d. gamma irradiator
9. The largest source of radiation in most people’s lives is ________.
   a. medical uses  
   b. natural background radiation  
   c. industrial applications  
   d. nuclear weapons testing

10. A radioactive gas that enters many houses from the ground below is ________.
   a. radium  
   b. radon  
   c. carbon-14  
   d. tritium

In the space provided, explain how the two terms in the following pairs differ from each other.

11. electron and positron

12. radioisotopes for diagnosis and for treatment

13. cancer cells and healthy cells

14. technetium-99m and technetium-99

15. behavior of carbon-12 and carbon-14 in a sugar molecule

16. a “labeled” compound and an “unlabeled” compound

17. level of background radiation and of radiation from human sources

18. ionizing and nonionizing radiation

19. gray and sievert