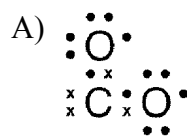
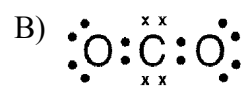
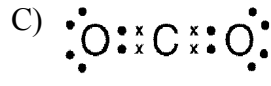
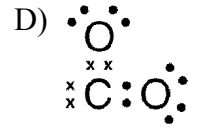
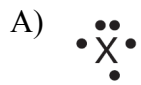
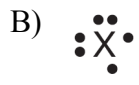
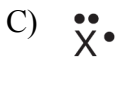
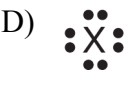


- Which subatomic particle will be attracted by a positively charged object?
  - proton
  - neutron
  - electron
  - positron
- An electron has a charge of
  - 1 and the same mass as a proton
  - +1 and the same mass as a proton
  - 1 and a smaller mass than a proton
  - +1 and a smaller mass than a proton
- Which conclusion is based on the "gold foil experiment" and the resulting model of the atom?
  - An atom is mainly empty space, and the nucleus has a positive charge.
  - An atom is mainly empty space, and the nucleus has a negative charge.
  - An atom has hardly any empty space, and the nucleus has a positive charge.
  - An atom has hardly any empty space, and the nucleus has a negative charge.
- Which sequence represents a correct order of historical developments leading to the modern model of the atom?
  - the atom is a hard sphere → most of the atom is empty space → electrons exist in orbitals outside the nucleus
  - the atom is a hard sphere → electrons exist in orbitals outside the nucleus → most of the atom is empty space
  - most of the atom is empty space → electrons exist in orbitals outside the nucleus → the atom is a hard sphere
  - most of the atom is empty space → the atom is a hard sphere → electrons exist in orbitals outside the nucleus
- An atom is electrically neutral because the
  - number of protons equals the number of electrons
  - number of protons equals the number of neutrons
  - ratio of the number of neutrons to the number of electrons is 1:1
  - ratio of the number of neutrons to the number of protons is 2:1
- A sample composed only of atoms having the same atomic number is classified as
  - a compound
  - a solution
  - a element
  - an isomer
- Compared to an atom of phosphorus-31, an atom of sulfur-32 contains
  - one less neutron
  - one less proton
  - one more neutron
  - one more proton
- What is the total charge of the nucleus of a carbon atom?
  - 6
  - 0
  - +6
  - +12
- The total mass of the protons in an atom of gold-198 is approximately
  - 79 atomic mass units
  - 119 atomic mass units
  - 198 atomic mass units
  - 277 atomic mass units
- Which two particles make up most of the mass of a hydrogen-2 atom?
  - electron and neutron
  - electron and proton
  - proton and neutron
  - proton and positron
- Atoms of different isotopes of the same element differ in their total number of
  - electrons
  - neutrons
  - protons
  - valence electrons
- The stability of an isotope is based on its
  - number of neutrons, only
  - number of protons, only
  - ratio of neutrons to protons
  - ratio of electrons to protons
- Hydrogen has three isotopes with mass numbers of 1, 2, and 3 and has an average atomic mass of 1.00794 amu. This information indicates that
  - equal numbers of each isotope are present
  - more isotopes have an atomic mass of 2 or 3 than of 1
  - more isotopes have an atomic mass of 1 than of 2 or 3
  - isotopes have only an atomic mass of 1
- The atomic mass of an element is calculated using the
  - atomic number and the ratios of its naturally occurring isotopes
  - atomic number and the half-lives of each of its isotopes
  - masses and the ratios of its naturally occurring isotopes
  - masses and the half-lives of each of its isotopes

15. How do the energy and the most probable location of an electron in the third shell of an atom compare to the energy and the most probable location of an electron in the first shell of the same atom?
- A) In the third shell, an electron has more energy and is closer to the nucleus.  
 B) In the third shell, an electron has more energy and is farther from the nucleus.  
 C) In the third shell, an electron has less energy and is closer to the nucleus.  
 D) In the third shell, an electron has less energy and is farther from the nucleus.
16. Compared to an electron in the first electron shell of an atom, an electron in the third shell of the same atom has
- A) less mass                      B) less energy  
 C) more mass                      D) more energy
17. Which electron configuration represents the electrons in an atom of chlorine in an excited state?
- A) 2-7-7    B) 2-7-8    C) 2-8-7    D) 2-8-8
18. Which electron configuration could represent a strontium atom in an excited state?
- A) 2-8-18-7-1                      B) 2-8-18-7-3  
 C) 2-8-18-8-1                      D) 2-8-18-8-2
19. Which electron configuration represents the electrons of an atom in an excited state?
- A) 2-8-1                              B) 2-8-6  
 C) 2-8-17-6                          D) 2-8-18-5
20. Which electron transition represents a gain of energy?
- A) from 2nd to 3rd shell  
 B) from 2nd to 1st shell  
 C) from 3rd to 2nd shell  
 D) from 3rd to 1st shell
21. Which of these phrases best describes an atom?
- A) a positive nucleus surrounded by a hard negative shell  
 B) a positive nucleus surrounded by a cloud of negative charges  
 C) a hard sphere with positive particles uniformly embedded  
 D) a hard sphere with negative particles uniformly embedded
22. The region that is the most probable location of an electron in an atom is
- A) the nucleus                      B) an orbital  
 C) the excited state                D) an ion
23. What determines the order of placement of the elements on the modern Periodic Table?
- A) atomic number  
 B) atomic mass  
 C) the number of neutrons, only  
 D) the number of neutrons and protons
24. Which substance can be decomposed by chemical means?
- A) tungsten                          B) antimony  
 C) krypton                            D) methane
25. Which substance can *not* be decomposed by ordinary chemical means?
- A) methane                            B) mercury  
 C) ethanol                            D) ammonia
26. Which element is classified as a nonmetal?
- A) Be    B) Al    C) Si    D) Cl
27. Which group in the Periodic Table contains elements that are all monatomic gases at STP?
- A) 15    B) 16    C) 17    D) 18
28. Which element is a solid at STP and a good conductor of electricity?
- A) iodine                              B) mercury  
 C) nickel                                D) sulfur
29. Which statement explains why ozone gas, O<sub>3</sub>, and oxygen gas, O<sub>2</sub>, have different properties?
- A) They are formed from different elements.  
 B) They have different molecular structures.  
 C) They have different oxidation numbers.  
 D) They have different electronegativities.
30. A 10.0-gram sample of which element has the *smallest* volume at STP?
- A) aluminum                          B) magnesium  
 C) titanium                            D) zinc
31. Which Lewis electron-dot diagram is correct for CO<sub>2</sub>?
- A)                       B) 
- C)                       D) 
32. An atom in the ground state contains a total of 5 electrons, 5 protons, and 5 neutrons. Which Lewis electron-dot diagram represents this atom?
- A)     B)     C)     D) 

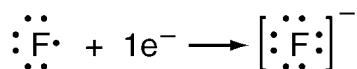
33. What is the total number of electrons found in an atom of sulfur?

- A) 6      B) 8      C) 16      D) 32

34. The charge of a beryllium-9 nucleus is

- A) +13      B) +9      C) +5      D) +4

35. Given the equation:



This equation represents the formation of a

- A) fluoride ion, which is smaller in radius than a fluorine atom  
 B) fluoride ion, which is larger in radius than a fluorine atom  
 C) fluorine atom, which is smaller in radius than a fluoride ion  
 D) fluorine atom, which is larger is radius than a fluoride ion

36. What is the total number of electrons in a  $\text{Cu}^{+}$  ion?

- A) 28      B) 29      C) 30      D) 36

37. Which list of elements is arranged in order of increasing atomic radii?

- A) Li, Be, B, C                      B) Sr, Ca, Mg, Be  
 C) Sc, Ti, V, Cr                    D) F, Cl, Br, I

38. Which trends are observed as each of the elements within Group 15 on the Periodic Table is considered in order from top to bottom?

- A) Their metallic properties decrease and their atomic radii decrease.  
 B) Their metallic properties decrease and their atomic radii increase.  
 C) Their metallic properties increase and their atomic radii decrease.  
 D) Their metallic properties increase and their atomic radii increase.

39. An ion of which element has a larger radius than an atom of the same element?

- A) aluminum                      B) chlorine  
 C) magnesium                    D) sodium

40. When an atom of phosphorus becomes a phosphide ion ( $\text{P}^{3-}$ ), the radius

- A) decreases                      B) increases  
 C) remains the same

41. Which of these elements has the *least* attraction for electrons in a chemical bond?

- A) oxygen                          B) fluorine  
 C) nitrogen                        D) chlorine

42. Which of the following elements has the highest electronegativity?

- A) H      B) K      C) Al      D) Ca

43. From which of these atoms in the ground state can a valence electron be removed using the *least* amount of energy?

- A) nitrogen                      B) carbon  
 C) oxygen                        D) chlorine

44. The amount of energy required to remove the outermost electron from a gaseous atom in the ground state is known as

- A) first ionization energy  
 B) activation energy  
 C) conductivity  
 D) electronegativity

45. Elements *Q*, *X*, and *Z* are in the same group on the Periodic Table and are listed in order of increasing atomic number. The melting point of element *Q* is  $-219^{\circ}\text{C}$  and the melting point of element *Z* is  $-7^{\circ}\text{C}$ . Which temperature is closest to the melting point of element *X*?

- A)  $-7^{\circ}\text{C}$                               B)  $-101^{\circ}\text{C}$   
 C)  $-219^{\circ}\text{C}$                         D)  $-226^{\circ}\text{C}$

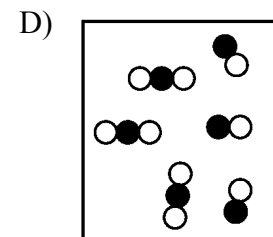
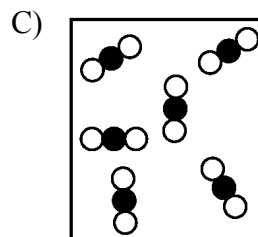
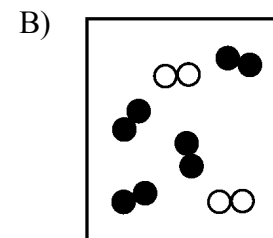
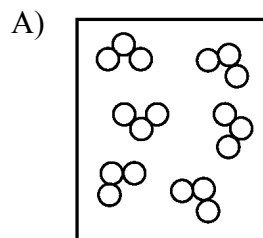
46. As the elements in Group 17 are considered in order of increasing atomic number, the chemical reactivity of each successive element

- A) decreases                      B) increases  
 C) remains the same

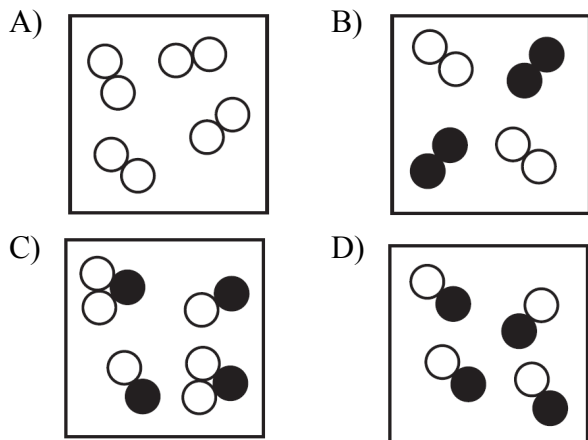
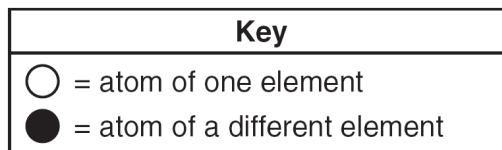
47. Given the simple representations for atoms of two elements:

- = an atom of an element  
 ● = an atom of a different element

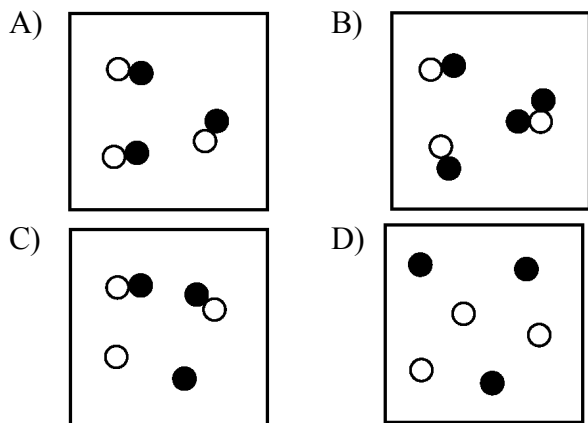
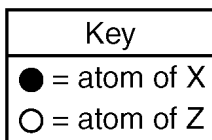
Which particle diagram represents molecules of only one compound in the gaseous phase?



48. Which particle diagram represents a sample of one compound, only?



49. Which particle diagram represents a mixture of element X and element Z, only?



50. Element X reacts with iron to form two different compounds with the formulas  $\text{FeX}$  and  $\text{Fe}_2\text{X}_3$ . To which group on the Periodic Table does element X belong?

- A) Group 8                      B) Group 2  
C) Group 13                     D) Group 16

51. What is the total number of different elements present in  $\text{NH}_4\text{NO}_3$ ?

- A) 7      B) 9      C) 3      D) 4

52. Which formula represents lead(II) chromate?

- A)  $\text{PbCrO}_4$                       B)  $\text{Pb}(\text{CrO}_4)_2$   
C)  $\text{Pb}_2\text{CrO}_4$                      D)  $\text{Pb}_2(\text{CrO}_4)_3$

53. Which group on the Periodic Table of the Elements contains elements that react with oxygen to form compounds with the general formula  $\text{X}_2\text{O}$ ?

- A) Group 1                      B) Group 2  
C) Group 14                     D) Group 18

54. What is the name of the polyatomic ion in the compound  $\text{Na}_2\text{O}_2$ ?

- A) hydroxide                     B) oxalate  
C) oxide                         D) peroxide

55. What is the molecular formula of a compound that has a molecular mass of 54 and the empirical formula  $\text{C}_2\text{H}_3$ ?

- A)  $\text{C}_2\text{H}_3$     B)  $\text{C}_4\text{H}_6$     C)  $\text{C}_6\text{H}_9$     D)  $\text{C}_8\text{H}_{12}$

56. Which formula is an empirical formula?

- A)  $\text{C}_2\text{H}_6$     B)  $\text{C}_4\text{H}_{10}$     C)  $\text{H}_2\text{O}$     D)  $\text{H}_2\text{O}_2$

57. Which list consists of types of chemical formulas?

- A) atoms, ions, molecules  
B) metals, nonmetals, metalloids  
C) empirical, molecular, structural  
D) synthesis, decomposition, neutralization

58. A sample of a compound contains 65.4 grams of zinc, 12.0 grams of carbon, and 48.0 grams of oxygen. What is the mole ratio of zinc to carbon to oxygen in this compound?

- A) 1:1:2    B) 1:1:3    C) 1:4:6    D) 5:1:4

59. What is the total number of oxygen atoms in the formula  $\text{MgSO}_4 \cdot 7 \text{H}_2\text{O}$ ? [The • represents seven units of  $\text{H}_2\text{O}$  attached to one unit of  $\text{MgSO}_4$ .]

- A) 11      B) 7      C) 5      D) 4

60. The molar mass of  $\text{Ba}(\text{OH})_2$  is

- A) 154.3 g                         B) 155.3 g  
C) 171.3 g                         D) 308.6 g

61. The gram formula mass of  $\text{NH}_4\text{Cl}$  is

- A) 22.4 g/mole                    B) 28.0 g/mole  
C) 53.5 g/mole                    D) 95.5 g/mole

62. The gram-formula mass of  $(\text{NH}_4)_2\text{CO}_3$  is

- A) 46.0 g                         B) 64.0 g  
C) 78.0 g                         D) 96.0 g

63. In which compound is the percent composition by mass of chlorine equal to 42%?

- A)  $\text{HClO}$  (gram-formula mass = 52 g/mol)  
B)  $\text{HClO}_2$  (gram-formula mass = 68 g/mol)  
C)  $\text{HClO}_3$  (gram-formula mass = 84 g/mol)  
D)  $\text{HClO}_4$  (gram-formula mass = 100. g/mol)

64. Which compound contains ionic bonds?

- A)  $\text{NO}$     B)  $\text{NO}_2$     C)  $\text{CaO}$     D)  $\text{CO}_2$

65. The percent composition by mass of magnesium in  $\text{MgBr}_2$  (gram-formula mass = 184 grams/mole) is equal to

- A)  $\frac{24}{184} \times 100$       B)  $\frac{160.}{184} \times 100$   
 C)  $\frac{184}{24} \times 100$       D)  $\frac{184}{160.} \times 100$

66. Which balanced equation represents a redox reaction?

- A)  $\text{CuCO}_3(\text{s}) \rightarrow \text{CuO}(\text{s}) + \text{CO}_2(\text{g})$   
 B)  $2\text{KClO}_3(\text{s}) \rightarrow 2\text{KCl}(\text{s}) + 3\text{O}_2(\text{g})$   
 C)  $\text{AgNO}_3(\text{aq}) + \text{KCl}(\text{aq}) \rightarrow \text{AgCl}(\text{s}) + \text{KNO}_3(\text{aq})$   
 D)  $\text{H}_2\text{SO}_4(\text{aq}) + 2\text{KOH}(\text{aq}) \rightarrow \text{K}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\ell)$

67. Which list includes three types of chemical reactions?

- A) condensation, double replacement, and sublimation  
 B) condensation, solidification, and synthesis  
 C) decomposition, double replacement, and synthesis  
 D) decomposition, solidification, and sublimation

68. A compound has a molar mass of 90. grams per mole and the empirical formula  $\text{CH}_2\text{O}$ . What is the molecular formula of this compound?

- A)  $\text{CH}_2\text{O}$       B)  $\text{C}_2\text{H}_4\text{O}_2$   
 C)  $\text{C}_3\text{H}_6\text{O}_3$       D)  $\text{C}_4\text{H}_8\text{O}_4$

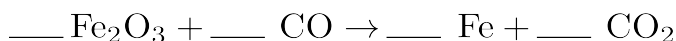
69. Which equation shows a conservation of mass?

- A)  $\text{Na} + \text{Cl}_2 \rightarrow \text{NaCl}$     B)  $\text{Al} + \text{Br}_2 \rightarrow \text{AlBr}_3$   
 C)  $\text{H}_2\text{O} \rightarrow \text{H}_2 + \text{O}_2$     D)  $\text{PCl}_5 \rightarrow \text{PCl}_3 + \text{Cl}_2$

70. Which chemical equation is correctly balanced?

- A)  $\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g})$   
 B)  $\text{N}_2(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{NH}_3(\text{g})$   
 C)  $2\text{NaCl}(\text{s}) \rightarrow \text{Na}(\text{s}) + \text{Cl}_2(\text{g})$   
 D)  $2\text{KCl}(\text{s}) \rightarrow 2\text{K}(\text{s}) + \text{Cl}_2(\text{g})$

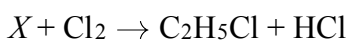
71. Given the unbalanced equation:



When the equation is correctly balanced using the *smallest* whole-number coefficients, what is the coefficient of  $\text{CO}$ ?

- A) 1    B) 2    C) 3    D) 4

72. Given the balanced equation:



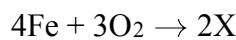
Which molecule is represented by  $X$ ?

- A)  $\text{C}_2\text{H}_4$     B)  $\text{C}_2\text{H}_6$     C)  $\text{C}_3\text{H}_6$     D)  $\text{C}_3\text{H}_8$

73. Which symbol represents a particle that has the same total number of electrons as  $\text{S}^{2-}$ ?

- A)  $\text{O}^{2-}$     B)  $\text{Si}$     C)  $\text{Se}^{2-}$     D)  $\text{Ar}$

74. Given the incomplete equation:



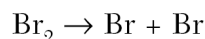
Which compound is represented by  $X$ ?

- A)  $\text{FeO}$       B)  $\text{Fe}_2\text{O}_3$   
 C)  $\text{Fe}_3\text{O}_2$       D)  $\text{Fe}_3\text{O}_4$

75. At STP, which sample contains the same number of molecules as 11.2 liters of  $\text{CO}_2(\text{g})$  at STP?

- A) 5.6L of  $\text{NO}_2(\text{g})$     B) 7.5 L of  $\text{H}_2(\text{g})$   
 C) 11.2 L of  $\text{N}_2(\text{g})$     D) 22.4 L of  $\text{CO}(\text{g})$

76. The balanced equation below represents a molecule of bromine separating into two bromine atoms.



What occurs during this change?

- A) Energy is absorbed and a bond is formed.  
 B) Energy is absorbed and a bond is broken.  
 C) Energy is released and a bond is formed.  
 D) Energy is released and a bond is broken.

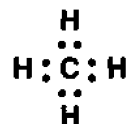
77. Given the balanced equation representing a reaction:



What occurs during this change?

- A) Energy is absorbed and a bond is broken.  
 B) Energy is absorbed and a bond is formed.  
 C) Energy is released and a bond is broken.  
 D) Energy is released and a bond is formed.

78. Given the Lewis electron-dot diagram:



Which electrons are represented by all of the dots?

- A) the carbon valence electrons, only  
 B) the hydrogen valence electrons, only  
 C) the carbon and hydrogen valence electrons  
 D) all of the carbon and hydrogen electrons

79. Based on electronegativity values, which type of elements tends to have the greatest attraction for electrons in a bond?

- A) metals      B) metalloids  
 C) nonmetals      D) noble gases

80. Which substance contains bonds that involved the transfer of electrons from one atom to another?

- A)  $\text{CO}_2$     B)  $\text{NH}_3$     C)  $\text{KBr}$     D)  $\text{Cl}_2$

81. Which formula represents an ionic compound?

- A)  $\text{H}_2$       B)  $\text{CH}_4$   
 C)  $\text{CH}_3\text{OH}$       D)  $\text{NH}_4\text{Cl}$

82. Which statement best describes the substance that results when electrons are transferred from a metal to a nonmetal?
- It contains ionic bonds and has a low melting point.
  - It contains ionic bonds and has a high melting point.
  - It contains covalent bonds and has a low melting point.
  - It contains covalent bonds and has a high melting point.
83. A solid substance was tested in the laboratory. The test results are listed below.
- dissolves in water
  - is an electrolyte
  - melts at a high temperature
- Based on these results, the solid substance could be
- Cu
  - CuBr<sub>2</sub>
  - C
  - C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>
84. Which substance is an electrolyte?
- CH<sub>3</sub>OH
  - C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>
  - H<sub>2</sub>O
  - KOH
85. The bond between Br atoms in a Br<sub>2</sub> molecule is
- ionic and is formed by the sharing of two valence electrons
  - ionic and is formed by the transfer of two valence electrons
  - covalent and is formed by the sharing of two valence electrons
  - covalent and is formed by the transfer of two valence electrons
86. Which two substances are covalent compounds?
- C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> (s) and KI(s)
  - C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> (s) and HCl(g)
  - KI(s) and NaCl(s)
  - NaCl(s) and HCl(g)
87. Which characteristic is a property of molecular substances?
- good heat conductivity
  - good electrical conductivity
  - low melting point
  - high melting point
88. The bonds between hydrogen and oxygen in a water molecule are classified as
- polar covalent
  - nonpolar covalent
  - ionic
  - metallic
89. Which statement correctly describes diamond and graphite, which are different forms of solid carbon?
- They differ in their molecular structure, only.
  - They differ in their properties, only.
  - They differ in their molecular structure and properties.
  - They do not differ in their molecular structure or properties.
90. The high electrical conductivity of metals is primarily due to
- high ionization energies
  - filled energy levels
  - mobile electrons
  - high electronegativities
91. Conductivity in a metal results from the metal atoms having
- high electronegativity
  - high ionization energy
  - highly mobile protons in the nucleus
  - highly mobile electrons in the valence shell
92. Which type of molecule is CF<sub>4</sub>?
- polar, with a symmetrical distribution of charge
  - polar, with an asymmetrical distribution of charge
  - nonpolar, with a symmetrical distribution of charge
  - nonpolar, with an asymmetrical distribution of charge
93. Which electron-dot structure represents a non-polar molecule?
- $$\begin{array}{c} \cdot\cdot \\ \text{H} : \text{Cl} : \\ \cdot\cdot \end{array}$$
  - $$\begin{array}{c} \text{H} \\ \cdot\cdot \\ \text{H} : \text{C} : \text{H} \\ \cdot\cdot \\ \text{H} \end{array}$$
  - $$\begin{array}{c} \cdot\cdot \\ \text{H} : \text{N} : \text{H} \\ \cdot\cdot \\ \text{H} \end{array}$$
  - $$\begin{array}{c} \cdot\cdot \\ \text{H} : \text{O} : \\ \cdot\cdot \\ \text{H} \end{array}$$
94. In aqueous solution, a chloride ion is attracted to which end of the water molecule?
- the hydrogen end, which is the positive pole
  - the hydrogen end, which is the negative pole
  - the oxygen end, which is the positive pole
  - the oxygen end, which is the negative pole
95. Which phase change is an exothermic process?
- CO<sub>2</sub>(s) → CO<sub>2</sub>(g)
  - NH<sub>3</sub>(g) → NH<sub>3</sub>(l)
  - Cu(s) → Cu(l)
  - Hg(l) → Hg(g)

96. Which substance has vibrating particles in regular, fixed positions?  
 A) Ca(s)                      B) Hg( $\ell$ )  
 C) Cl<sub>2</sub>(g)                      D) CaCl<sub>2</sub>(aq)
97. The burning of magnesium involves a conversion of  
 A) chemical energy to mechanical energy  
 B) chemical energy to heat energy  
 C) heat energy to chemical energy  
 D) heat energy to mechanical energy
98. Which term is defined as a measure of the average kinetic energy of the particles in a sample?  
 A) temperature              B) pressure  
 C) thermal energy          D) chemical energy
99. The boiling point of a liquid is the temperature at which the vapor pressure of the liquid is equal to the pressure on the surface of the liquid. What is the boiling point of propanone if the pressure on its surface is 48 kilopascals?  
 A) 25°C   B) 30.°C   C) 35°C   D) 40.°C
100. As carbon dioxide sublimates, its entropy  
 A) decreases                  B) increases  
 C) remains the same
101. At STP, a sample of which element has the highest entropy?  
 A) Na(s)                      B) Hg( $\ell$ )  
 C) Br<sub>2</sub>( $\ell$ )                      D) F<sub>2</sub>(g)
102. A sample of a gas is contained in a closed rigid cylinder. According to kinetic molecular theory, what occurs when the gas inside the cylinder is heated?  
 A) The number of gas molecules increases.  
 B) The number of collisions between gas molecules per unit time decreases.  
 C) The average velocity of the gas molecules increases.  
 D) The volume of the gas decreases.
103. Under which conditions of temperature and pressure would helium behave most like an ideal gas?  
 A) 50 K and 20 kPa      B) 50 K and 600 kPa  
 C) 750 K and 20 kPa    D) 750 K and 600 kPa
104. Helium is most likely to behave as an ideal gas when it is under  
 A) high pressure and high temperature  
 B) high pressure and low temperature  
 C) low pressure and high temperature  
 D) low pressure and low temperature
105. A sample of gas is held at constant pressure. Increasing the kelvin temperature of this gas sample causes the average kinetic energy of its molecules to  
 A) decrease and the volume of the gas sample to decrease  
 B) decrease and the volume of the gas sample to increase  
 C) increase and the volume of the gas sample to decrease  
 D) increase and the volume of the gas sample to increase
106. A sample of helium gas has a volume of 900. milliliters and a pressure of 2.50 atm at 298 K. What is the new pressure when the temperature is changed to 336 K and the volume is decreased to 450. milliliters?  
 A) 0.177 atm                  B) 4.43 atm  
 C) 5.64 atm                      D) 14.1 atm
107. Which physical changes are endothermic?  
 A) melting and freezing  
 B) melting and evaporating  
 C) condensation and sublimation  
 D) condensation and deposition
108. What is the total number of joules released when a 5.00-gram sample of water changes from liquid to solid at 0°C?  
 A) 334 J                          B) 1670 J  
 C) 2260 J                          D) 11 300 J
109. According to Reference Table *H*, what is the boiling point of ethanoic acid at 80 kPa?  
 A) 28°C                          B) 100°C  
 C) 111°C                          D) 125°C
110. In which process does a solid change directly into a vapor?  
 A) condensation              B) sublimation  
 C) deposition                  D) solidification
111. Based on intermolecular forces, which of these substances would have the highest boiling point?  
 A) He    B) O<sub>2</sub>    C) CH<sub>4</sub>    D) NH<sub>3</sub>
112. At standard pressure, a certain compound has a low boiling point and is insoluble in water. At STP, this compound most likely exists as  
 A) ionic crystals              B) metallic crystals  
 C) nonpolar molecules      D) polar molecules

113. The table below shows the normal boiling point of four compounds.

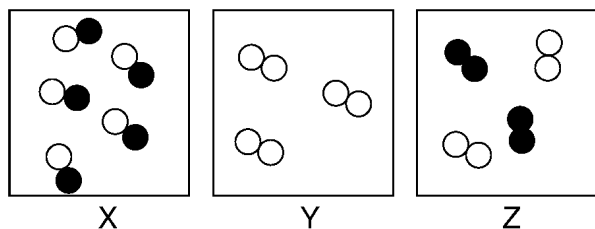
Compound	Normal Boiling Point (°C)
HF( <i>l</i> )	19.4
CH <sub>3</sub> Cl( <i>l</i> )	-24.2
CH <sub>3</sub> F( <i>l</i> )	-78.6
HCl( <i>l</i> )	-83.7

Which compound has the strongest intermolecular forces?

- A) HF(*l*)                      B) CH<sub>3</sub>Cl(*l*)  
 C) CH<sub>3</sub>F(*l*)                 D) HCl(*l*)
114. Which statement explains why H<sub>2</sub>O has a higher boiling point than N<sub>2</sub>?
- A) H<sub>2</sub>O has greater molar mass than N<sub>2</sub>.  
 B) H<sub>2</sub>O has less molar mass than N<sub>2</sub>.  
 C) H<sub>2</sub>O has stronger intermolecular forces than N<sub>2</sub>.  
 D) H<sub>2</sub>O has weaker intermolecular forces than N<sub>2</sub>.
115. Which of these terms refers to matter that could be heterogeneous?

- A) element                    B) mixture  
 C) compound                D) solution

116. Given the diagrams X, Y, and Z below:



Key
Atom of element A = ○
Atom of element B = ●

Which diagram or diagrams represent a mixture of elements A and B?

- A) X, only                      B) Z, only  
 C) X and Y                    D) X and Z
117. When a mixture of water, sand, and salt is filtered, what passes through the filter paper?
- A) water, only  
 B) water and sand, only  
 C) water and salt, only  
 D) water, sand, and salt

118. Which process would most effectively separate two liquids with different molecular polarities?

- A) filtration                    B) fermentation  
 C) distillation                D) conductivity

119. Which ion, when combined with chloride ions, Cl<sup>-</sup>, forms an insoluble substance in water?

- A) Fe<sup>2+</sup>    B) Mg<sup>2+</sup>    C) Pb<sup>2+</sup>    D) Zn<sup>2+</sup>

120. Solubility data for four different salts in water at 60°C are shown in the table below.

Salt	Solubility in Water at 60°C
A	10 grams / 50 grams H <sub>2</sub> O
B	20 grams / 60 grams H <sub>2</sub> O
C	30 grams / 120 grams H <sub>2</sub> O
D	40 grams / 80 grams H <sub>2</sub> O

Which salt is most soluble at 60°C?

- A) A    B) B    C) C    D) D

121. According to your Reference Tables, which substance forms an unsaturated solution when 80 grams of the substance is dissolved in 100 grams of H<sub>2</sub>O at 10°C?

- A) KI                              B) KNO<sub>3</sub>  
 C) NaNO<sub>3</sub>                      D) NaCl

122. At room temperature, the solubility of which solute in water would be most affected by a change in pressure?

- A) methanol                    B) sugar  
 C) carbon dioxide            D) sodium nitrate

123. A student adds solid KCl to water in a flask. The flask is sealed with a stopper and thoroughly shaken until no more solid KCl dissolves. Some solid KCl is still visible in the flask. The solution in the flask is

- A) saturated and is at equilibrium with the solid KCl  
 B) saturated and is not at equilibrium with the solid KCl  
 C) unsaturated and is at equilibrium with the solid KCl  
 D) unsaturated and is not at equilibrium with the solid KCl

124. A solution contains 35 grams of KNO<sub>3</sub> dissolved in 100 grams of water at 40°C. How much *more* KNO<sub>3</sub> would have to be added to make it a saturated solution?

- A) 29 g    B) 24 g    C) 12 g    D) 4g

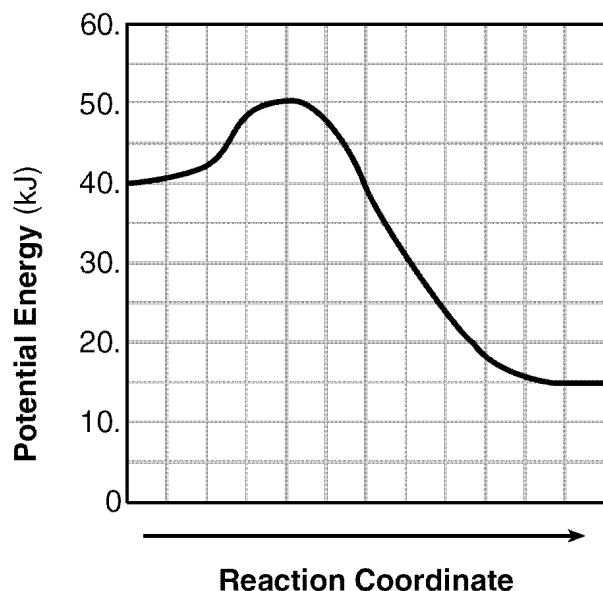
125. What is the molarity of a solution of NaOH if 2 liters of the solution contains 4 moles of NaOH?

- A) 0.5 M    B) 2 M    C) 8 M    D) 80 M



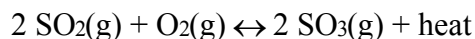
126. A saturated solution of  $\text{NaNO}_3$  is prepared at  $60.^\circ\text{C}$  using 100. grams of water. As this solution is cooled to  $10.^\circ\text{C}$ ,  $\text{NaNO}_3$  precipitates (settles) out of the solution. The resulting solution is saturated. Approximately how many grams of  $\text{NaNO}_3$  settled out of the original solution?  
A) 46 g B) 61 g C) 85 g D) 126 g
127. What is the total number of grams of  $\text{NaI}$ (s) needed to make 1.0 liter of a 0.010 M solution?  
A) 0.015 B) 0.15 C) 1.5 D) 15
128. What is the concentration of a solution, in parts per million, if 0.02 gram of  $\text{Na}_3\text{PO}_4$  is dissolved in 1000 grams of water?  
A) 20 ppm B) 2 ppm  
C) 0.2 ppm D) 0.02 ppm
129. Compared to a 2.0 M aqueous solution of  $\text{NaCl}$  at 1 atmosphere, a 3.0 M aqueous solution of  $\text{NaCl}$  at 1 atmosphere has a  
A) lower boiling point and a higher freezing point  
B) lower boiling point and a lower freezing point  
C) higher boiling point and a higher freezing point  
D) higher boiling point and a lower freezing point
130. Which event must *always* occur for a chemical reaction to take place?  
A) formation of a precipitate  
B) formation of a gas  
C) effective collisions between reacting particles  
D) addition of a catalyst to the reaction system
131. In most aqueous reactions as temperature increases, the effectiveness of collisions between reacting particles  
A) decreases B) increases  
C) remains the same
132. A 5.0-gram sample of zinc and a 50.-milliliter sample of hydrochloric acid are used in a chemical reaction. Which combination of these samples has the fastest reaction rate?  
A) a zinc strip and 1.0 M  $\text{HCl}$ (aq)  
B) a zinc strip and 3.0 M  $\text{HCl}$ (aq)  
C) zinc powder and 1.0 M  $\text{HCl}$ (aq)  
D) zinc powder and 3.0 M  $\text{HCl}$ (aq)
133. At STP, which 4.0-gram zinc sample will react fastest with dilute hydrochloric acid?  
A) lump B) bar  
C) powdered D) sheet metal
134. For a given reaction, adding a catalyst increases the rate of the reaction by  
A) providing an alternate reaction pathway that has a higher activation energy  
B) providing an alternate reaction pathway that has a lower activation energy  
C) using the same reaction pathway and increasing the activation energy  
D) using the same reaction pathway and decreasing the activation energy
135. A student observed that the temperature of water increased when a salt was dissolved in it. The student should conclude that dissolving the salt was  
A) involved in the formation of an acidic solution  
B) involved in the formation of a basic solution  
C) an exothermic reaction  
D) an endothermic reaction
136. Which expression represents the  $\Delta H$  for a chemical reaction in terms of the potential energy,  $PE$ , of its products and reactants?  
A)  $PE$  of products +  $PE$  of reactants  
B)  $PE$  of products –  $PE$  of reactants  
C)  $PE$  of products  $\times$   $PE$  of reactants  
D)  $PE$  of products  $\div$   $PE$  of reactants
137. In a chemical reaction, the difference between the potential energy of the products and the potential energy of the reactants is defined as the  
A) activation energy  
B) ionization energy  
C) heat of reaction  
D) heat of vaporization
138. Which statement must be true for any chemical reaction at equilibrium?  
A) The concentration of the products is greater than the concentration of the reactants.  
B) The concentration of the products is less than the concentration of the reactants.  
C) The concentration of the products and the concentration of the reactants are equal.  
D) The concentration of the products and the concentration of the reactants are constant.
139. A solution that is at equilibrium must be  
A) concentrated B) dilute  
C) saturated D) unsaturated
140. The vapor pressure of a liquid is 0.92 atm at  $60^\circ\text{C}$ . The normal boiling point of the liquid could be  
A)  $35^\circ\text{C}$  B)  $45^\circ\text{C}$  C)  $55^\circ\text{C}$  D)  $65^\circ\text{C}$

141. Given the potential energy diagram for a chemical reaction:



Which statement correctly describes the energy changes that occur in the forward reaction?

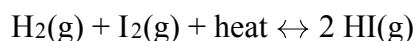
- A) The activation energy is 10. kJ and the reaction is endothermic.  
 B) The activation energy is 10. kJ and the reaction is exothermic.  
 C) The activation energy is 50. kJ and the reaction is endothermic.  
 D) The activation energy is 50. kJ and the reaction is exothermic.
142. Given the reaction at equilibrium:



Which change will shift the equilibrium to the right?

- A) increasing the temperature  
 B) increasing the pressure  
 C) decreasing the amount of  $\text{SO}_2(\text{g})$   
 D) decreasing the amount of  $\text{O}_2(\text{g})$
143. Given the system at equilibrium:  
 $2 \text{POCl}_3(\text{g}) + \text{energy} \rightleftharpoons 2 \text{PCl}_3(\text{g}) + \text{O}_2(\text{g})$   
 Which changes occur when  $\text{O}_2(\text{g})$  is added to this system?
- A) The equilibrium shifts to the right and the concentration of  $\text{PCl}_3(\text{g})$  increases.  
 B) The equilibrium shifts to the right and the concentration of  $\text{PCl}_3(\text{g})$  decreases.  
 C) The equilibrium shifts to the left and the concentration of  $\text{PCl}_3(\text{g})$  increases.  
 D) The equilibrium shifts to the left and the concentration of  $\text{PCl}_3(\text{g})$  decreases.

144. What occurs when the temperature is increased in a system at equilibrium at constant pressure?
- A) The rate of the forward reaction increases, and the rate of the reverse reaction decreases.  
 B) The rate of the forward reaction decreases, and the rate of the reverse reaction increases.  
 C) The rate of the endothermic reaction increases.  
 D) The rate of the exothermic reaction decreases.
145. Given the equilibrium reaction in a closed system:



What will be the result of an increase in temperature?

- A) The equilibrium will shift to the left and  $[\text{H}_2]$  will increase.  
 B) The equilibrium will shift to the left and  $[\text{H}_2]$  will decrease.  
 C) The equilibrium will shift to the right and  $[\text{HI}]$  will increase.  
 D) The equilibrium will shift to the right and  $[\text{HI}]$  will decrease.
146. In terms of energy and entropy, systems in nature tend to undergo changes toward
- A) higher energy and higher entropy  
 B) higher energy and lower entropy  
 C) lower energy and higher entropy  
 D) lower energy and lower entropy
147. A student calculates the density of an unknown solid. The mass is 10.04 grams, and the volume is 8.21 cubic centimeters. How many significant figures should appear in the final answer?
- A) 1      B) 2      C) 3      D) 4
148. Which mass measurement contains four significant figures?
- A) 0.086 g                      B) 0.431 g  
 C) 1003 g                        D) 3870 g
149. Expressed to the correct number of significant figures, the sum of two masses is 445.2 grams. Which two masses produce this answer?
- A) 210.10 g + 235.100 g  
 B) 210.100 g + 235.10 g  
 C) 210.1 g + 235.1 g  
 D) 210.10 g + 235.10 g

150. A student calculated the percent by mass of water in a hydrate as 14.2%. A hydrate is a compound that contains water as part of its crystal structure. If the accepted value is 14.7%, the student's percent error was

A)  $\frac{0.5}{14.2} \times 100$

B)  $\frac{14.7}{14.2} \times 100$

C)  $\frac{0.5}{14.7} \times 100$

D)  $\frac{14.2}{14.7} \times 100$