1. _____ Which separation technique would be used to separate the colors in a mixture?
        a. decanting   b. magnetism   c. distillation   d. chromatography

2. _____ Some bottles of colorless liquids were being labeled when the technicians accidentally mixed them up and lost track of their contents. A 24.8 mL sample withdrawn from one bottle weighed 22.3 g. Which of the following is the correct identity of the unknown liquid?
        a. acetone, d=0.792 g/mL   b. benzene, 0.899 g/mL
        c. chloroform, d=1.489 g/mL   d. carbon tetrachloride, d=1.595 g/mL

3. _____ The proper scientific notation for 56,500,000,000 is —
        a. 0.565×10^{11} b. 5.65×10^{10} c. 5.65×10^{-10} d. 565×10^{-8}

4. _____ Deposition is an example of an:
        a. exothermic chemical change   b. endothermic physical change
        c. endothermic chemical change   d. exothermic physical change

5. _____ A student is given a container of potassium nitrate crystals. In order to determine the exact mass of the potassium nitrate using a balance, he must know the —
    a. mass of the filled container and the chemical formula for potassium nitrate
    b. mass of the filled container and the density of potassium nitrate
    c. volume of the filled container and the volume of the potassium nitrate
    d. mass of the empty container and the mass of the filled container

6. _____ One of the outermost electrons in a strontium atom in the ground state can be described by which of the following sets of four quantum numbers?
(A) 5, 2, 0, ½   (B) 5, 1, 1, ½   (C) 5, 1, 0, ½   (D) 5, 0, 1, ½   (E) 5, 0, 0, ½

7. _____ Which type of radiation continues in a straight line when passed through an electric field?
(A) alpha   (B) gamma   (C) beta   (D) proton   (E) positron

8. _____ For the types of radiation given, which of the following is the correct order of **increasing** ability to penetrate a piece of lead?
(A) Alpha particles < gamma rays < beta particles   (B) Alpha particles < beta particles < gamma rays
(C) Beta particles < alpha particles < gamma rays   (D) Beta particles < gamma rays < alpha particles
        (E) Gamma rays < alpha particles < beta particles

9. _____ Correct statements about alpha particles include which of the following?
    I. They have a mass number of 4 and a charge of +2.
    II. They are more penetrating than beta particles.
    III. They are helium nuclei.
(A) I only   (B) III only   (C) I and II   (D) I and III   (E) II and III

10. _____ If 87.5 percent of a sample of pure ^{131}I decays in 24 days, what is the half-life of ^{131}I?
(A) 6 days   (B) 8 days   (C) 12 days   (D) 14 days   (E) 21 days

11. _____ . $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{55}Cs + 3\,^{1}_{0}n + X$
Neutron bombardment of uranium can induce the following reaction represented above. Nuclide X is which of the following?
(A) $^{92}_{35}Br$ (B) $^{94}_{35}Br$ (C) $^{91}_{37}Rb$ (D) $^{92}_{37}Rb$ (E) $^{94}_{37}Rb$

12. _____ Experiments performed to reveal the structure of atoms led scientists to conclude that an atom's
(A) positive charge is evenly distributed throughout its volume
(B) negative charge is mainly concentrated in its nucleus
(C) mass is evenly distributed throughout its volume
(D) volume is mainly unoccupied

(E) positive and negative charges are concentrated in the nucleus

13. _____ What is the maximum number of electrons that occupy the n = 3 level?
(A) 6 　　　　(B) 8 　　　　(C) 10 　　　　(D) 18 　　　　(E) 32

14. _____ Which set of quantum numbers (n, l, ml, ms) is **NOT** permitted by the rules of quantum mechanics?
(A) 1, 0, 0, +½ 　(B) 2, 1, −1, −½ 　　(C) 3, 3, 1, −½ 　(D) 4, 3, 2, +½ 　(E) 4, 1, -1, +½

15. _____ How many unpaired electrons are in an iron atom in its ground state?
(A) 6 　　　　(B) 5 　　　　(C) 4 　　　　(D) 2 　　　　(E) 0

16. _____ An electron in an atom will emit energy (light) when it moves from energy level:
(A) 2s to 2p 　　(B) 1s to 2s 　　(C) 2p to 3s 　　(D) 2p to 1s 　　(E) 3d to 4f

17. _____ Which of the following represents the ground state electron configuration for the Mn^{3+} ion?
(A) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^4$ 　　　(B) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^5\ 4s^2$ 　　(C) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^2\ 4s^2$
(D) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^8\ 4s^2$ 　　　　　　　　　　(E) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^3\ 4s^1$

18. _____ The electron configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ corresponds to the electron configuration of:
(A) S^{2-} 　　　(B) Ca^{2+} 　　　(C) Cl^- 　　　(D) K^+ 　　　(E) all of these

19. _____ Which of the following has the largest value for the second ionization energy?
(A) sodium 　　(B) chlorine 　　(C) sulfur 　　(D) aluminum 　(E) magnesium

20. _____ Which of the following has the largest electron affinity?
(A) sodium 　　(B) chlorine 　　(C) sulfur 　　(D) aluminum 　(E) magnesium

21. _____ In which of the following are the elements listed in order of increasing ionization energy?
(A) B, Be, C, N 　　　　　(B) F, Cl, Br, I 　　　　　(C) O, N, C, B
(D) Mg, Al, Si, P 　　　　　(E) N,O, F, Ne

| Ionization Energies for element X (kJ mol^{-1}) | | | | |
First	Second	Third	Fourth	Five
580	1815	2740	11600	14800

22. _____ The ionization energies for element X are listed in the table above. On the basis of the data, element X is most likely to be:
(A) Na 　　　(B) Mg 　　　(C) Al 　　　(D) Si 　　　(E) P

23. _____ In which of the following are the elements listed in order of increasing Electronegativity?
(A) Ba, Zn, C, Cl 　　　　　(B) N, O, S, Cl 　　　　　(C) N, P, As, Sb
(D) K, Ba, Si, Ga 　　　　　(E) Li, K, Na, Ca

24. _____ In the periodic table, as the atomic number increases from 11 to 17, what happens to the atomic radius?
(A) It remains constant. 　　　(B) It increases only. 　　　(C) It increases, then decreases.
(D) It decreases only. 　　　(E) It decreases, then increases.

25. _____ Which of the following elements has one valence electron?
(A) helium 　　(B) chlorine 　　(C) chromium 　(D) aluminum 　(E) zinc

26. _____Which of the following substances can conduct electricity at room temperature?
　　I. Mg 　　　　II. $CuCl_2$ 　　　　　III. Cu

(A) II only 　　(B) I and II only (C) I and III only 　　　　(D) II and III only 　　(E) I, II, and III

27. _____ What is the oxidation number of phosphorus in copper(II) phosphite?
(A) +2 　　　(B) +3 　　　(C) -3 　　　　(D) +4 　　　　(E) +5

28. _____ Which of the following is true about ionic compounds?
　　I. They are most crystalline solids at room temperature.
　　II. They only conduct electricity when dissolved in water.

III. They have free moving electrons.

(A) I only   (B) I and II only (C) I and III only   (D) II and III only   (E) I, II, and III

29. _____When LiF is formed from its elements there are five steps. Which of the following steps is NOT endothermic?
        I. Step 1: Sublimation of solid lithium. $Li(s) \rightarrow Li(g)$
        II. Step 2: Ionization of lithium atom. $Li(g) \rightarrow Li^+(g) + e^-$
        III . Step 4: Formation of fluoride ions. $F(g) + e^- \rightarrow F^-(g)$

(A) II only   (B) II only   (C) I and II only   (D) II and III only   (E) III only

30. _____ Which of the following would likely have the highest melting point?
(A) LiCl   (B) LiF   (C) NaCl   (D) NaF   (E) KF

31. _____ What is the oxidation number of sulfur in aluminum sulfate?
(A) +3   (B) -2   (C) +2   (D) +4   (E) +6

32. _____ What is the oxidation number of manganese in MnO_2?
(A) +2   (B) +3   (C) +4   (D) +6   (E) +7

33. _____ What is the oxidation number of ruthenium in RuO_3?
(A) +3   (B) +2   (C) +6   (D) +4   (E) +8

34. _____ Which of the following is an ionic bond?
    a. H-O   b. P-F   c. C-O   d. O-K

35. _____ Which of the following intermolecular forces explains why fluorine is a gas, but iodine is a solid?
    a. dispersion forces   b. dipole interactions   c. hydrogen bonds   d. covalent bonds

36. _____ Which of the following molecules would have the most hydrogen bonding?
    a. H_2O b. H_2 c. CH_4 d. HCN

37. _____ Which of the following molecules has the strongest dispersion forces?
    a. H_2 b. I_2 c. Br_2 d. F_2

38. _____ Which of the following compounds does not have a resonance structure?
    a. sulfur dichloride   b. nitrate ion   c. sulfur dioxide   d. carbonate ion

39. _____ Which of the following elements does not follow the octet rule?
    a. carbon   b. nitrogen   c. hydrogen   d. iodine

40. _____ Which of the following bonds is the longest?
    a. single bond   b. double bond   c. triple bond   d. all bonds are the same length

41. _____ Which of the following best describes the bond between chlorine and bromine in BrCl?
    a. polar single covalent bond   b. non-polar single covalent bond
    c. polar double covalent bond   d. non-polar covalent bond

42. _____ Which of the following molecules has the strongest bonds between atoms?
    a. H_2 b. F_2 c. O_2 d. N_2

43. _____ A compound contains 1.10 mol of K, 0.55 mol of Te, and 1.65 mol of O. What is the simplest formula of this compound?
(A) KTeO   (B) KTe_2O (C) K_2TeO_3 (D) K_2TeO_6 (E) K_4TeO_6

44. _____ How many carbon atoms are contained in 2.8 grams of C_2H_4?
(A) 1.2×10^{23} (B) 3.0×10^{23} (C) 6.0×10^{23} (D) 1.2×10^{24} (E) 6.0×10^{24}

45. _____ What is the empirical formula of a hydrocarbon that is 10% hydrogen by mass?

(A) CH_3 (B) C_2H_5 (C) C_3H_4 (D) C_4H_9 (E) C_9H_{10}

46. _____ How many gold atoms are there in 25.0 grams of gold?
(A) 25.0×10^{23} (B) 2.96×10^{27} (C) 7.64×10^{22} (D) 560.   (E) none of the above

47. _____ What is the percentage of oxygen in iron(III) oxide?
(A) 69.9%   (B) 77.7%   (C) 30.1%   (D) 22.3%   (E) none of the above

48. _____ What is the mass of silver in 356 grams of silver nitrate($AgNO_3$)?
(A) 226 grams   (B) 68.5 grams   (C) 63.5 grams (D) 30.3 grams (E) none of the above

49. _____ How many sulfate ions are there in 111 grams of aluminum sulfate?
(A) 1.95×10^{23} (B) 3.90×10^{23} (C) 5.86×10^{23} (D) 2.98×10^{24} (E) none of the above

50. _____ What is the formula of a compound that is 62.5 % strontium, 14.7 % phosphorus & 22.8% oxygen?
(A) $SrPO_3$ (B) $Sr_3(PO_3)_2$ (C) $Sr_3(PO_4)_2$ (D) Sr_3PO_4 (E) $Sr_3(PO_2)_2$

51. _____ What is the mass of 126 liters of diatomic oxygen at STP?
(A) 5.62 grams   (B) 180. grams   (C) 88.2 grams   (D) 90.0 grams (E) none of the above

52. _____ The percentage of calcium (by mass) in calcium fluoride is:
(A) 51%   (B) 40%   (C) 68%   (D) 33%   (E) 81%

53. _____ $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ - Using 32.0 grams of methane Lisa was able to produce 63.0 grams of water. Calculate her percent yield?
     a. 17.5%   b. 57.1%   c. 77.8%   d. 87.5%   e. none of the above

54. _____ $3H_2 + N_2 \rightarrow 2NH_3$ - Given 28.1 grams of N_2 and 30.0 liters of H_2, which is your limiting reagent?
     a. N_2 b. H_2 c. NH_3 d. both H_2 & N_2 e. can't be determined

55. _____ $2Al + 3S \rightarrow Al_2S_3$ - Aluminum reacts with sulfur to produce aluminum sulfide. If I have 81 grams of Al and 81 grams of S, what is my limiting reagent?
     a. S   b. Al   c. Al_2S_3 d. both Al & S   e. can't be determined

56. _____ $2KClO_3 \rightarrow 2KCl + 3O_2$ - Potassium chlorate decomposes to form potassium chloride and oxygen gas. How many liters of oxygen gas at STP are produced from 490.4 grams of potassium chlorate?
     a. 59.7 L   b. 134 L   c. 192 L   d. 268 L   e. none of the above

57. _____ If the theoretical value is 4.75 grams and in the lab you measure 3.23 grams, what is the percent yield?
a. 1.52 %   b. 1.47 %   c. 68.0 %   d. 87.4 %   e. none of the above

58. _____ $2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$
The reaction above is not spontaneous at standard conditions, but becomes spontaneous as the temperature decreases towards absolute zero. Which of the following is true at standard conditions?
     (A) ΔS and ΔH are both negative
     (B) ΔS and ΔH are both positive
     (C) ΔS is negative and ΔH is positive
     (D) ΔS is positive and ΔH is negative
     (E) ΔS and ΔH are both equal to zero

59. _____ $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
Based on the information in the table below, what is the ΔH for the above reaction?

Bond	Average Bond Energy (kJ/mol)
H-H	432
O=O	495
O-H	467

     (A) +460 kJ   (B) +425 kJ   (C) +509 kJ   (D) -509 kJ   (E) -460 kJ

60. _____ Based on the information given below, what is the ΔH for the following reaction:

$C_2H_2(g) + 5/2\ O_2 \rightarrow 2CO_2(g) + H_2O$
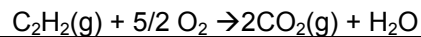
Reaction	ΔH
$C(s) + O_2(g) \rightarrow CO_2(g)$	$\Delta H = -390$ kJ/mol
$H_2(g) + \frac{1}{2}\ O_2(g) \rightarrow H_2O(l)$	$\Delta H = -290$ kJ/mol
$2C(s) + H_2(g) \rightarrow C_2H_2(g)$	$\Delta H = +230$ kJ/mol

(A) -1300 kJ   (B) -1070 kJ   (C) -840 kJ   (D)-780 kJ   (E) -680 kJ

61._____ The addition of a catalyst will have which of the following effects on a chemical reaction?
  I.   The enthalpy will decrease.
  II.   The entropy will decrease.
  III.   The activation energy will decrease.
(A) I only   (B) II only   (C) III only   (D) I and II only   (E) II and III only

62._____ For which of the following processes will ΔS be positive?
  I. $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$
  II. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
  III. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
(A) I only   (B) II only   (C) I and II only   (D) I and III only   (E) 1, II and III

63._____ Complete combustion of a sample of a hydrocarbon in excess oxygen produces the same coefficients for carbon dioxide and water. Which of the following could be the molecular formula of the compound?
(A) CH_4 (B) C_2H_6 (C) C_2H_2 (D) C_4H_8 (E) C_6H_6

64. _____ Zn(s) is used to reduce other compounds in chemical reactions. If a chemist needs a substance that is more effective in its reducing ability, which of the following species would be the best choice?
(A) Na   (B) H^+ (C) K^+ (D) Cl^- (E) F^-

65. _____ Oxygen is acting as an oxidizing agent in all of the following reactions EXCEPT:
(A) $2\ C(s) + O_2(g) \rightarrow 2\ CO(g)$ (B) $S(s) + O_2(g) \rightarrow SO_2(g)$
(C) $2\ F_2(g) + O_2(g) \rightarrow 2\ OF_2(g)$ (D) $2\ Na(s) + O_2(g) \rightarrow Na_2O_2(s)$
                (E) $2\ Mg(s) + O_2(g) \rightarrow 2\ MgO(s)$

66. _____   … $C_3H_8(g)$ + … $O_2(g) \rightarrow$ … $H_2O(g)$ + … $CO_2(g)$
When the equation for the reaction represented above is balanced and all coefficients are reduced to the lowest whole-number terms, the coefficient for $O_2(g)$ is:
(A) 1   (B) 2   (C) 3   (D) 5   (E) 6

67. _____ When heated, metallic carbonates generally produce:
(A) metallic peroxide + CO   (B) metal + CO + O_2 (C) metallic hydroxide + CO_2
          (D) metallic oxalate + O_2 (E) metallic oxide + CO_2

68._____ A 5.00 M solution with a volume of 400. mL is left uncovered and 75.0 mL evaporates. What is the new molarity of the solution?
          (A) 6.15 M   (B) 26.7 M   (C) 4.21 M   (D) 5.00 M   (E) 5.33

69._____ A 580. mL solution contains 120. mL of ethanol (C_2H_5OH). Calculate the volume percent of this solution.
          (A) 20.7%   (B) 4.83%   (C) 7.47%   (D) 4.50%   (E) 0.207%

70._____ A solution of 2.250 grams of an unknown molecular compound in 18.12 grams of camphor freezes at a temperature 12.2 Celsius degrees below the normal freezing point of pure camphor. Determine the molar mass of the unknown substance. K_f, for camphor is 40.0 kg-K-mol^{-1}.
       (A) 407 g/mol   (B) 204 g/mol   (C) 102 g/mol   (D) 305 g/mol   (E) 30.5 g/mol

71._____ How many kilograms of water are needed to make a 1.5 molal solution using 70.0 grams of $CaCl_2$?
       (A) 0.95 kg   (B) 0.42 kg   (C) 2.4 kg   (D) 47 kg   (E) 0.047 kg

72._____
       I. Difference in temperature between freezing point of solvent and freezing point of solution
       II. Molal freezing point depression constant, K_f, for solvent
In addition to the information above, which of the following gives the minimum data required to determine the molecular mass of a nonionic substance by the freezing point depression technique?
       (A) No further information is necessary.   (B) Mass of solute
       (C) Mass of solute and mass of solvent   (D) Mass of solute and volume of solvent
         (E) Mass of solute, mass of solvent, and vapor pressure of solvent

73._____ A solution of 2.250 grams of an unknown molecular compound in 18.12 grams of camphor freezes at a temperature 12.2 Celsius degrees below the normal freezing point of pure camphor. Determine the molar mass of the unknown substance. K_f, for camphor is 40.0 kg-K-mol^{-1}.
       (A) 407 g/mol   (B) 204 g/mol   (C) 102 g/mol   (D) 305 g/mol   (E) 30.5 g/mol

74._____ How many kilograms of water are needed to make a 1.5 molal solution using 70.0 grams of $CaCl_2$?
       (A) 0.95 kg   (B) 0.42 kg   (C) 2.4 kg   (D) 47 kg   (E) 0.047 kg

75._____
       I. Difference in temperature between freezing point of solvent and freezing point of solution
       II. Molal freezing point depression constant, K_f, for solvent
In addition to the information above, which of the following gives the minimum data required to determine the molecular mass of a nonionic substance by the freezing point depression technique?
       (A) No further information is necessary.   (B) Mass of solute
       (C) Mass of solute and mass of solvent   (D) Mass of solute and volume of solvent
         (E) Mass of solute, mass of solvent, and vapor pressure of solvent

76._____ A solution of toluene(C_7H_8) and benzene(C_6H_6) is prepared. If the mole fraction of toluene is 0.25, what is the mole fraction of benzene?
       (A) 25   (B) 0.25   (C) 0.75   (D) 0.29   (E) 0.71

77._____ What is the percent mass of a solution that has 73.0 grams of NaCl dissolved in 275 grams of solution?
       (A) 0.265 %   (B) 26.5%   (C) 0.476%   (D) 7.55%   (E) 4.57%

78. A 3.00-liter flask initially contains 1.50 mol of gas A and 0.450 mol of gas B. Gas A decomposes according to the following reaction: $3A \rightleftharpoons 2B + C$ The equilibrium concentration of gas C is 0.100 mol/L. Determine the equilibrium concentration of gas A.
(a) 0.200 M   (b) 0.100 M   (c) 0.300 M   (d) 0.500 M   (e) none of these

79. The equilibrium constant for the reaction: $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$ is 26 at 50°C. What is the K_c for $3CO_2(g) + 3H_2(g) \rightleftharpoons 3CO(g) + 3H_2O(g)$ at the same temperature?
(a) 0.34   (b) 5.7×10^{-5} (c) 0.038   (d) 1.8×10^4 (e) 2.9

80. $H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$
Initially, a sealed vessel contained only $H_2(g)$ with a partial pressure of 6 atm and $CO_2(g)$ with a partial pressure of 4 atm. The reaction above was allowed to come to equilibrium at a temperature of 700 K. At equilibrium, the partial pressure due to CO(g) was found to be 2 atm. What is the value of the equilibrium constant K_p, for the reaction?
(a) $\dfrac{1}{24}$ (b) $\dfrac{1}{6}$ (c) $\dfrac{1}{4}$ (d) $\dfrac{1}{3}$ (e) $\dfrac{1}{2}$

81. _____ The solubility product, K_{sp}, of CaF_2 is 4×10^{-11}. Which of the following expressions is equal to the solubility of CaF_2?

(A) $\sqrt{4x10^{-11}}$ M (B) $\sqrt{2x10^{-11}}$ M (C) $\sqrt[3]{4x10^{-11}}$ M

(D) $\sqrt[3]{2x10^{-11}}$ M (E) $\sqrt[3]{1x10^{-11}}$ M

82. _____ How many moles of calcium fluoride, CaF_2, must be dissolved in 2.0 L of water at 25°C to form a saturated solution? CaF_2 1.6×10^{-10} K_{sp} at 25 °C

(A) 2.6×10^{-2} mol (B) 1.3×10^{-3} mol (C) 6.8×10^{-4} mol

(D) 3.4×10^{-4} mol (E) 1.6×10^{-10} mol

83. _____ The ionization of benzoic acid is represented by this equation.

$C_6H_5COOH(aq) \rightleftharpoons H^+(aq) + C_6H_5COO^-(aq)$
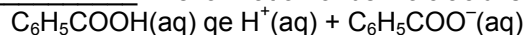
If a 0.045 M solution of benzoic acid has an $[H^+] = 1.7 \times 10^{-3}$, what is the K_a of benzoic acid?

(A) 7.7×10^{-5} (B) 6.7×10^{-5} (C) 3.8×10^{-2}

(D) 8.4×10^{-1} (E) 2.9×10^{-6}

84. _____ $C_6H_5OH(aq) + CN^-(aq) \rightleftharpoons HCN(aq) + C_6H_5O^-(aq)$

The equilibrium constant for this reaction is less than 1. What is the strongest base in this system?

(A) $C_6H_5OH(aq)$ (B) $CN^-(aq)$ (C) $HCN(aq)$

(D) $C_6H_5O^-(aq)$ (E) all bases are equal in strength

85. _____ What is the conjugate base of $H_2PO_4^-$?

(A) $HPO_4^{2-}(aq)$ (B) $H_2O(l)$ (C) $HPO_4^-(aq)$

(D) $H_3PO_4(aq)$ (E) HPO_4