For 1 – 4:
  a. The point of equilibrium
  b. The triple point
  c. The freezing point
  d. The point where reactants first form products
  e. The boiling point

1. a specific temperature and pressure where solid, liquid, and gas phases exist simultaneously
2. can be shifted by adding more reactants
3. vapor pressure of a liquid is equal to the pressure of the surroundings
4. the activated complex

For 5 – 8:
  a. red
  b. purple
  c. orange
  d. green
  e. blue

5. copper(II) sulfate solution
6. chlorine gas
7. $KMnO_4$ solution
8. bromine solution

For 9 – 11:
  a. voltaic cell
  b. electrolytic cell
  c. Geiger counter
  d. pH meter
  e. calorimeter

9. requires an external current to make a redox reaction spontaneous
10. requires a salt bridge
11. detects radioactive particles

For 12 – 15:
  a. halogens
  b. alkali metals
  c. alkaline earth metals
  d. noble gases
  e. lanthanides

12. valence electrons are located in the f orbitals
13. need to lose one electron to form a stable octet
14. will have the highest first ionization energies
15. contain elements in the solid, liquid and gas phases at STP

For 16 – 19:
  a. 9.03×10^{23} molecules
  b. 44.8 liters
  c. 3.5 moles
  d. 6.0 grams
  e. 3.01×10^{23} atoms

16. 0.25 moles of O_2 at STP
17. 3.0 moles of H_2 at STP
18. 56 grams of N_2 at STP
19. 96.0 grams of SO_2 at STP

For 20 – 22:
  a. Water
  b. Hydrogen bromide
  c. Iron
  d. Argon
  e. Sodium chloride

20. hydrogen bonding
21. dipoles
22. dispersion forces

For 23 – 25:
  a. alpha particle
  b. beta particle
  c. gamma particle
  d. positron
  e. deuteron

23. Po-218 → At-218 + X
24. Tc-99 → Tc-99 + X
25. Ne-19 → F-19 + X

Q	Statement I	Because	Statement II
26.	An element's nuclear charge is equal to the number of protons in the nucleus	Because	The only charged particles in the nucleus are neutrons
27.	A reaction will be spontaneous if ΔH is negative and ΔS is positive	Because	ΔG will be negative when there is a decrease in enthalpy and an increase in entropy
28.	Cl⁻ is the conjugate base of HCl	Because	A conjugate base is formed when an acid gains a proton
29.	An electrolytic cell makes a nonspontaneous redox reaction occur	Because	An electrolytic cell uses an external current to drive a redox reaction
30.	The maximum number of electrons allowed in the third principal energy level is 18	Because	The maximum number of electrons allowed in a principal energy level is dictated by the equation $2n^2$
31.	3000 kilogramsis equal to 3 grams	Because	The prefix *kilo-* means "one thousandth"
32.	An increase in temperature will cause a gas to expand	Because	Temperature and volume have a direct relationship
33.	A catalyst will change the heat of reaction	Because	A catalyst will lower the potential energy of the activated complex in a reaction
34.	Helium will have fewer dispersion forces between its atoms than the other noble gases	Because	As the mass of nonpolar atoms and molecules increases, dispersion forces increase
35.	nitrogen gas will have a greater rate of effusion than oxygen gas	Because	Lighter, less dense gases travel faster than heavier, more dense gases
36.	Propane can be decomposed chemically	Because	Propane is a compound that is made up of simpler elements
37.	A mixture of two different liquids can be separated via distillation	Because	Different liquids have different boiling points
38.	Isotopes have different atomic numbers	Because	Isotopes must have different numbers of electrons
39.	Butene can be converted into butane	Because	The addition reaction of hydrogen gas to an alkene will form and alkane
40.	NaCl is a basic salt	Because	Hydrolysis of NaCl reveals the formation of NaOH and HCl

41. When 58 grams of water is heated from 275 K to 365 K, the water
  a. Absorbs 21,820 J
  b. Absorbs 377 J
  c. Releases 5,220 J
  d. Absorbs 242 J
  e. Releases 90 J

42. Which of the following are uses for radiation and radioactivity that are of benefit to us?
  i. Nuclear waste
  ii. Radioisotopes
  iii. Excess exposure

  a. i only
  b. ii only
  c. iii only
  d. i and ii only
  e. i and iii only

43. Which of the following statements is not part of the kinetic molecular theory?
  a. The average kinetic energy of gas molecules is directly proportional to temperature.
  b. Attractive and repulsive forces are present between gas molecules.
  c. Collisions between gas molecules are perfectly elastic.
  d. Gas molecules travel in a continuous, random motion.
  e. The volume that gas molecules occupy is minimal compared to the volume within which the gas is contained.

44. The following redox reaction occurs in an acidic solution: $Ce^{4+} + Bi \rightarrow Ce^{3+} + BiO^+$. What is the coefficient before the

Ce^{4+} when the equation is fully balanced?
a. 1
b. 2
c. 3
d. 6
e. 9

45. Which statement regarding significant figures is false?
a. Zeros can be significant
b. When multiplying, the answer is determined by the number of significant figures
c. When adding, the answer is determined by the number of decimal places
d. When dividing, the answer is determined by the number of decimal places
e. The number 50,004 has five significant figures

46. Which statement below best describes the molecule in question?
a. Water has a bent molecular geometry and one lone pair of electrons
b. Ammonia has a trigonal pyramidal molecular geometry and two long pairs of electrons
c. Methane has a trigonal planar molecular geometry
d. Carbon dioxide is linear because it has one single bond and one triple bond
e. The carbon atoms in ethane are sp^3 hybridized

47. A compound was analyzed and found to be 12.1% C, 71.7% Cl, and 16.2% O. What is the empirical formula for this compound?
a. C_2OCl
b. $COCl$
c. CO_2Cl_2
d. C_2O_2Cl
e. CCl_2O

48. Which statement is true about the percent composition by mass of $C_6H_{12}O_6$?
a. Carbon is 6.7% by mass
b. Oxygen is 53.3% by mass
c. Hydrogen is 12% by mass
d. Carbon is 72% by mass
e. Carbon is 20% by mass

**49.** Which process would have a positive value for the change in entropy?
i. The expansion of the universe
ii. The condensation of a liquid
iii. A food fight in a school cafeteria
a. i only
b. ii only
c. iii only
d. ii and iii only
e. i and iii only

50. Of the gases below, which would react with rain water to produce acid rain?
i. CFCs
ii. Methane
iii. Carbon dioxide
a. i only
b. ii only
c. iii only
d. i and iii only
e. i, ii and iii

51. A sample of gas is trapped in a manometer and the stopcock is opened. The level of mercury moves to a new height as can be seen in the diagram. If the pressure of the gas inside the manometer is 815 torr, what is the atmospheric pressure in this case?
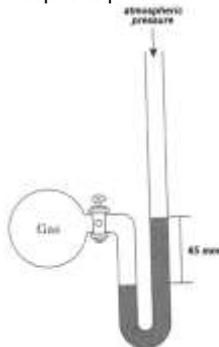
a. 760 torr
b. 740 torr
c. 750 torr
d. 815 torr
e. 880 torr

52. Which aqueous solution is expected to have the highest boiling point?
a. 1.5 m $FeCl_2$
b. 3.0 m CH_3OH
c. 2.5 m $C_6H_{12}O_6$
d. 2.5 m $NaCl$
e. 1.0 m $CaCl_2$

53. Which K_a value is that of a better electrolyte?
a. 1.0×10^{-2}
b. 2.0×10^{-12}
c. 5.0×10^{-7}
d. 3.0×10^{-4}
e. 1.0×10^{-6}

54. The following substances were all dissolved in 100 grams of water at 290 K to produce saturated solutions. If the solution is heated to 310 K, which substance will have a decrease in its solubility.
a. NaCl
b. KI
c. $CaCl_2$
d. HCl
e. KNO_3

55. Methane undergoes a combustion reaction according to the reaction $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$. How many grams of methane gas were burned if 67.2

liters of carbon dioxide gas are produced in the reaction? (assume STP)
a. 16 grams
b. 48 grams
c. 3 grams
d. 132 grams
e. 22.4 grams

56. A closed system contains the following reaction at STP: $Cl_2(g) + 2NO_2(g) \rightleftharpoons 2NO_2Cl(g)$. What is the equilibrium constant expression for this reaction?

a. $K_{eq} = \dfrac{[NO_2Cl]^2}{[Cl_2][NO_2]}$

b. $K_{eq} = \dfrac{[Cl_2][NO_2]^2}{[NO_2Cl]}$

c. $K_{eq} = \dfrac{[Cl_2][NO_2]^2}{[NO_2Cl]^2}$

d. $K_{eq} = \dfrac{[NO_2Cl]^2}{[Cl_2][NO_2]^2}$

e. $K_{eq} = \dfrac{[NO_2Cl]^2}{[Cl_2]^2[NO_2]^2}$

57. At a particular temperature, the equilibrium concentrations of the substances in the previous question are as follows: $[NO_2Cl] = 0.5$ M, $[Cl_2] = 0.3$ M, $[NO_2] = 0.2$ M. What is the value of the equilibrium constant for this reaction?
a. 2.1
b. 0.48
c. 0.0357
d. 20.83
e. 208.83

58. Which Lewis structure below has been drawn incorrectly?
a. H : H
b. H : C ⋮⋮ N :
c. H : Ö : \\ H
d. : N ⋮⋮ N :
e. F : B : F \\ F

59. Which reaction below demonstrates the Lewis definition of acids and bases?
a. $HCl + NaOH \rightarrow HOH + NaCl$
b. $H_2O + NH_3 \rightarrow OH^- + NH_4^+$
c. $NH_3 + BF_3 \rightarrow NH_3BF_3$
d. $HI + KOH \rightarrow H_2O + KI$
e. $H^+ + OH^- \rightarrow H_2O$

60. Which sample is a homogeneous mixture?
a. $KI(aq)$
b. $Fe(s)$
c. $CO_2(g)$
d. $NH_3(l)$
e. $NaCl(s)$

61. Which pair below represents isomers of the same compound?

a. $CH_3CH_2CH_2OH$ and $HOCH_2CH_2CH_3$
b. $CH_3CH_2CH_3$ and $CH_3CH_2CH_2CH_3$
c. $CH_3CH(Cl)CH_3$ and $CH_3CH_2CH_2Cl$
d. CH_3COCH_3 and $CH_3CH_2CH_2CHO$
e. $ClCH_2CH_2Br$ and $BrCH_2CH_2Cl$

62. Which would you never to in a laboratory setting?
i. Eat and drink in the laboratory
ii. Push a thermometer through a rubber stopper
iii. Remove your goggles to take a better look at a reaction
  a. i only
  b. ii only
  c. iii only
  d. i and iii only
  e. i, ii and iii

63. How many pi bonds are there in a molecule of $N≡C-CH_2-CH_2-CO-NH-CH=CH_2$
  a. 7
  b. 4
  c. 12
  d. 10
  e. 5

64. When the equation: $C_2H_6 + O_2 \rightarrow CO_2 + H_2O$ is completely balanced using the lowest whole number coefficients, the sum of the coefficients will be
  a. 4
  b. 9.5
  c. 19
  d. 15.5
  e. 11

65. From the heats of reaction of these individual reactions:
$A + B \rightarrow 2C$ $\quad \Delta H = -500$ kJ
$D + 2B \rightarrow E$ $\quad \Delta H = -700$ kJ
$2D + 2A \rightarrow F$ $\quad \Delta H = +50$ kJ
Find the heat of reaction for $F + 6B \rightarrow 2E + 4C$
  a. +450 kJ
  b. -1100 kJ
  c. +2350 kJ
  d. -350 kJ
  e. -2450 kJ

66. Which solutions have a concentratoin of 1.0 M?
i. 74 grams of calcium hydroxide dissolved to make 1 liter of solution
ii. 74.5 grams of potassium chloride dissolved to maek 1 liter of solution
iii. 87 grams of lithium bromide dissolved to make 1 liter of solution
  a. i only
  b. iii only
  c. i and iii only
  d. ii and iii only
  e. i, ii and iii

67. According to the reaction $3H_2 + N_2 \rightarrow 2NH_3$, how many grams of hydrogen gas and nitrogen gas are needed to make exactly 68 grams of ammonia?
  a. 2 grams of hydrogen gas and 28 grams of nitrogen gas
  b. 3 grams of hydrogen gas and 1 gram of nitrogen gas
  c. 12 grams of hydrogen gas and 56 grams of nitrogen gas
  d. 102 grams of hydrogen gas and 34 grams of nitrogen gas
  e. 6 grams of hydrogen gas and 2 grams of nitrogen gas

68. Which compound is not paired with its correct name?
  a. $FeCl_2$ / iron(II) chloride
  b. K_2O / potassium oxide
  c. NO_2 / nitrogen dioxide
  d. PCl_3 / potassium trichloride
  e. NH_4Cl / ammonium chloride

69. How many grams of HI can be made from 6 grams of H_2 and 800 grams of I_2 in the following reaction: $H_2 + I_2 \rightarrow 2HI$?
  a. 800 grams of HI can be made with 38 grams of excess iodine
  b. 768 grams of HI can be made with 6 grams of excess hydrogen
  c. 768 grams of HI can be made with 38 grams of excess iodine
  d. 2286 grams of HI can be made with no excess reactants
  e. 806 grams of HI can be made with no excess reactants

70. 500 mL of a 0.2 M solution has 200 mL of water added to it. What is the new molarity of this solution?
  a. 0.50 M
  b. 0.28 M
  c. 0.70 M
  d. 0.14 M
  e. 0.40 M

71. Which mixture is correctly paired with a method for separation of the mixture?
  a. Oil and water—filter paper
  b. Salt water—distillation
  c. Sand and water—separatory funnel
  d. Sand and sugar—tweezers
  e. Sugar water—filter paper

72. Which reaction between ions does not form a precipitate?
  a. Ag^+ and Cl^-
  b. Pb^{2+} and $2I^-$
  c. Ca^{2+} and CO_3^{2-}
  d. Hg^{2+} and $2Br^-$
  e. Na^+ and OH^-

73. Which will happen when sodium sulfate is added to a saturated solution of $CaSO_4$ that is at equilibrium? $[CaSO_4(s) \rightleftharpoons Ca^{2+}(aq) + SO_4^{2-}(aq)]$
  a. The solubility of the calcium sulfate will decrease
  b. The concentration of calcium ikons will increase
  c. The reaction will shift to the right
  d. The K_{sp} value will change
  e. The equilibrium will shift to consume the decrease in sulfate ions.

74. Given the reaction $2A(g) + B(g) + heat \rightleftharpoons 3C(g) + D(g)$, what could be done to the reaction to shift the equilibrium so that more D is made?
  a. Increase the concentration of D
  b. Increase the concentration of C
  c. Increase the temperature
  d. Increase the pressure
  e. Remove B from the reaction

75. A 16-gram sample of water at 273 K is cooled so that it becomes a completely solid ice cube at 273 K. How much heat was released by the sample of water to form this ice cube?
  a. 16 J
  b. 4368 J
  c. 18258 J
  d. 350 J
  e. 5334 J

76. Sublimation is the process by which a solid becomes a gas without having a liquid phase. Which of these substances can sublime?
i. Iodine
ii. Naphthalene
iii. Carbon dioxide
  a. i only
  b. ii only
  c. iii only
  d. i and iii only
  e. i, ii and iii

77. Which of the following will decrease the rate of a reaction?
  a. Using powdered solids instead of whole pieces
  b. Selecting ionic reactants that have been dissolved in water
  c. Decreasing the temperature
  d. Increasing the pressure
  e. Adding a catalyst

78. Three gases are mixed in a sealed container. The container has 0.3 moles of gas A, 0.4 moles of gas B, and 0.3 moles of gas C. The total pressure of the gases is 660 torr. What is true about the partial pressures of the gases?
  a. The partial pressure of gas A is 264 torr
  b. The partial pressure of gas B is 396 torr
  c. The partial pressure of gas C is 220 torr
  d. The partial pressures of gases A and C are each 198 torr
  e. The partial pressure of gas B is 660 torr
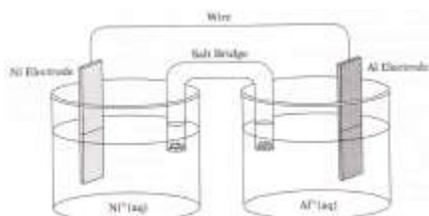
79. In the diagram above, what is the half reaction that occurs at the cathode?
- a. $Al \rightarrow Al^{3+} + 3e^-$
- b. $Ni^{2+} + 2e^- \rightarrow Ni$
- c. $Ni \rightarrow Ni^{2+} + 2e^-$
- d. $2Al^{3+} + 6e^- \rightarrow 2Al$
- e. $Al^{3+} + 3e^- \rightarrow Al$

80. For the diagram above, which statement is true about the setup shown?
- a. The electrode potential for this cell is 1.40 V
- b. The electrode potential for this cell is 2.54 V
- c. Electrons will be carried by the salt bridge
- d. Ions will be carried through the wire
- e. The reaction is nonspontaneous

81. Over a number of years the average pH of a stream changes from a pH of 6.9 to a pH of 5.9 due to acid rain. Which statement is true about the pH of the stream?
- a. The pH of the stream now is one times more acidic than it was years ago
- b. The stream now has 10 times more hydroxide ions than it did years ago
- c. The pH of the stream is now 10 times more acidic than it was years ago
- d. The stream is more basic now than it was years ago
- e. The concentration of hydronium ion in the stream has decreased over the years

82. An alkaline earth metal, element M, reacts with oxygen. What is going to be the general formula for the compound formed?
- a. M_2O
- b. MO
- c. MO_2
- d. M_2O_3
- e. M_3O_2

83. Which functional group below does not contain a carbonyl group?
- a. Aldehydes
- b. Ketones
- c. Esters
- d. Ethers
- e. Carboxylic acids

84. Using the bond dissociation energies found at the end, calculate the change in the heat of reaction for $2H_2 + O_2 \rightarrow 2H_2O$.
- a. -118 kJ
- b. +118 kJ
- c. -91 kJ
- d. -1042 kJ
- e. -833 kJ

85. Equilibrium
- a. Is defined as equal concentrations of reactants and products
- b. Is defined as equal rates for forward and reverse reactions
- c. Can be shifted by adding a catalyst
- d. Can exist for chemical changes but not for physical changes
- e. Must always favor the formation of products

ANSWERS:

1.	B	14.	D	26.	T F	39.	T T CE	52.	D	65.	E	78.	D
2.	A	15.	A	27.	T T CE	40.	F T	53.	A	66.	E	79.	B
3.	E	16.	E	28.	T F	41.	A	54.	D	67.	C	80.	A
4.	D	17.	D	29.	T T CE	42.	B	55.	B	68.	D	81.	C
5.	E	18.	B	30.	T T CE	43.	B	56.	D	69.	C	82.	B
6.	D	19.	A	31.	F F	44.	C	57.	D	70.	D	83.	D
7.	B	20.	A	32.	T T CE	45.	D	58.	E	71.	B	84.	E
8.	A	21.	B	33.	F T	46.	E	59.	C	72.	E	85.	B
9.	B	22.	D	34.	T T CE	47.	E	60.	A	73.	A		
10.	A	23.	B	35.	T T CE	48.	B	61.	C	74.	C		
11.	C	24.	C	36.	T T CE	49.	E	62.	E	75.	E		
12.	E	25.	D	37.	T T CE	50.	C	63.	B	76.	E		
13.	B			38.	F F	51.	C	64.	C	77.	C		

Bond energies:

Bond	kJ/mol
C—C	349
C—Cl	329
C—H	412
C=O	798
Cl—Cl	240
H—Cl	430
H—H	435
N—H	390
N—N	163
N≡N	941
O—H	462
O—O	145

Standard Electrode Potentials for Elements on the Activity Series

Nonmetals

$F_2 + 2e^- \rightarrow 2F^-$	+2.87 V
$Cl_2 + 2e^- \rightarrow 2Cl^-$	+1.51 V
$Br_2 + 2e^- \rightarrow 2Br^-$	+1.06 V
$I_2 + 2e^- \rightarrow 2I^-$	+0.54 V

Metals

$Li^+ + 1e^- \rightarrow Li$	-3.05 V
$K^{1+} + 1e^- \rightarrow K$	-2.93 V
$Na^{1+} + 1e^- \rightarrow Na$	-2.71 V
$Mg^{2+} + 2e^- \rightarrow Mg$	-2.37 V
$Al^{3+} + 3e^- \rightarrow Al$	-1.66 V
$Zn^{2+} + 2e^- \rightarrow Zn$	-0.76 V
$Cr^{3+} + 3e^- \rightarrow Cr$	-0.74 V
$Fe^{2+} + 2e^- \rightarrow Fe$	-0.45 V
$Co^{2+} + 2e^- \rightarrow Co$	-0.28 V
$Ni^{2+} + 2e^- \rightarrow Ni$	-0.26 V
$Sn^{2+} + 2e^- \rightarrow Sn$	-0.14 V
$Pb^{2+} + 2e^- \rightarrow Pb$	-0.13 V
$2H^+ + 2e^- \rightarrow H_2$	0.00 V*
$Cu^{2+} + 2e^- \rightarrow Cu$	+0.34 V
$Ag^{1+} + 1e^- \rightarrow Ag$	+0.80 V
$Au^{3+} + 3e^- \rightarrow Au$	+1.50 V

*Denotes arbitrary standard.