For 1 – 4:

a.

b.

c.

d.

e.
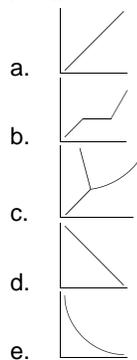
1. Demonstrates the relationship between pressure (x-axis) and volume (y-axis) in Boyle's Law
2. Contains a triple point
3. Demonstrates the relationship between temperature (x-axis) and volume (y-axis) in Charles' Law
4. Shows the relationship between atomic number (x-axis) and atomic radius (y-axis) for the elements in period 2

For 5 – 8:
   a. Br_2 and Hg
   b. Cl_2 and F_2
   c. NH_4^+ and H_3O^+
   d. Fe and Co
   e. Diamond and graphite

5. these two compounds are in the liquid phase at 293 K
6. these two compounds have coordinate covalent bonds
7. these two compounds are allotropes of each other
8. these two compounds are good oxidizing agents

For 9 – 11:
   a. R—OH
   b. R—O—R
   c. R—NH_2
   d. R—COO—R
   e. R—CO—R

9. ends in –*oate*
10. ends in –*amine*
11. ends in –*ol*

For 12 – 15:
   a. $1s^2 2s^2 2p^6 3s^2 3p^6$
   b. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
   c. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
   d. $1s^2$
   e. $1s^2 2s^2 2p^6 3p^1$

12. the electron configuration for calcium ion
13. the electron configuration for an excited atom
14. the electron configuration for potassium in the ground state
15. the electron configuration for the noble gas with the highest first ionization energy

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For 16 – 19:
   a. sublimation
   b. deposition
   c. vaporization
   d. condensation
   e. freezing

16. solid to gas
17. gas to solid
18. liquid to gas
19. liquid to solid

For 20 – 22:
   a. nitrogen
   b. oxygen
   c. chlorine
   d. neon
   e. beryllium

20. has 2 valence electrons
21. has 6 valence electrons
22. will form an ion with a 3-charge

For 23 – 25:
   a. milli-
   b. kilo-
   c. centi-
   d. micro-
   e. nano-

23. 10^{-9}
24. 10^{-6}
25. 10^3

A = **T**rue **T**rue **CE**   B = **T**rue **T**rue   C = **T**rue **F**alse   D = **F**alse **T**rue   E = **F**alse **F**alse

Q	Statement I	Because	Statement II
26.	Alpha particles are able to pass through a thin sheet of gold foil	Because	The atom is mainly empty space
27.	Nitrogen has five valence electrons	Because	The electron configuration for nitrogen is $1s^2 2s^2 2p^6$
28.	A molecule of ethyne is linear	Because	The carbon atoms in ethyne are sp hybridized
29.	KNO_3 will not dissolve in water	Because	All chlorides are soluble in water
30.	CCl_4 is a polar molecule	Because	The dipole arrows for CCl_4 show counterbalance and symmetry
31.	According to the equation $M_1V_1 = M_2V_2$, as the volume increases the molarity decreases	Because	As water is added to a solution the solution is diluted
32.	HCl is an Arrhenius acid	Because	HCl will yield hydronium ions as the only positive ions in solution
33.	Adding more reactants will speed up a reaction	Because	The reactants will collide less frequently
34.	$Al^{3+} + 3e^- \rightarrow Al$ is a correctly balanced oxidation reaction	Because	$Al^{3+} + 3e^- \rightarrow Al$ correctly demonstrates conservation of mass and conservation of charge
35.	^4_2He is the correct symbol for an alpha particle	Because	An alpha particle is a helium-3 nucleus
36.	Fluorine has the highest value for electronegativity	Because	Fluorine has the greatest attraction for electrons
37.	The number 5,007 has three significant figures	Because	Zeros between non-zero digits are significant
38.	DNA is a polymer	Because	DNA has many smaller units bonded to create longer chains
39.	Radiation and radioisotopes can have beneficial uses	Because	Radioisotopes and radiation can be used for radio dating, radiotracers, and food preservation
40.	A $1m$ NaCl(aq) solution will freeze at a temperature below 273 K	Because	As a solute is added to a solvent, the boiling point increases while the freezing point decreases

41. When chlorine gas and hydrogen gas react to form hydrogen chloride, what will be the change of enthalpy of the reaction? (bond energies are at the end of this test)
a. +245 kJ/mol
b. +185 kJ/mol
c. -185 kJ/mol
d. -1105 kJ/mol
e. +1105 kJ/mol

42. How much heat is required to raise the temperature of 85 grams of water from 280 K to 342 K?
a. 5270 J
b. 355 J
c. 259 J
d. 151 J
e. 22029 J

43. Which of the following is not part of the Atomic Theory?
a. Compounds are made up of combinations of atoms
b. All atoms of a given element are alike
c. All matter is composed of atoms
d. A chemical reaction involves the rearrangement of atoms
e. The atom is mainly empty space

44. Which of the following compounds will have an atom with a molecular geometry that is described as trigonal planar with respect to other atoms present?
i. BF_3
ii. $CH_2=CH_2$
iii. cyclopropane
a. i only
b. ii only
c. iii only
d. i and ii only
e. i, ii, and iii

45. Which of the following transmutations demonstrate(s) beta decay?
i. Bi-212 → Po-212
ii. Pb-212 → Bi-212
iii. Ra-228 → Ac-228
a. i only
b. ii only
c. ii and iii only
d. i and ii only
e. i, ii and iii

46. A liquid will boil when
a. The liquid is hot
b. A salt has been added to the liquid
c. The vapor pressure of the liquid is equal to the surrounding pressure
d. The vapor pressure is reduced

e. The surrounding pressure is increased

47. Which sample has atoms that are arranged in a regular geometric pattern?
a. KCl(l)
b. $NaC_2H_3O_2(s)$
c. Fe(l)
d. NaCl(aq)
e. HCl(aq)

48. Which aqueous solution has a molarity of 1.0 M?
a. 73 grams of HCl dissolved to make 2.0 liters of solution
b. 360 grams of $C_6H_{12}O_6$ dissolved to make 1.5 liters of solution
c. 94 grams of K_2O dissolved to make 0.75 liters of solution
d. 24 grams of LiOH dissolved to make 1.25 liters of solution
e. 40 grams of HF dissolved to make 2.50 liters of solution

49. Which double replacement reaction forms an insoluble precipitate?
a. HCl(aq) + KOH(aq) →
b. $KNO_3(aq) + Na_2SO_4(aq) →$
c. $NaCl(aq) + CaCl_2(aq) →$
d. $AgNO_3(aq) + KCl(aq) →$
e. $KBr(aq) + H_2O(aq) →$

50. Of the following solutions, which one is expected to be the weakest electrolyte?
a. HCl(aq)
b. HF(aq)
c. NaOH(aq)
d. KI(aq)
e. $HClO_4(aq)$

51. Which of the following indicate(s) a basic solution?
i. Litmus paper turns blue
ii. Phenolphthalein turns pink
iii. Hydronium ion concentration is greater than hydroxide ion concentration
a. i only
b. ii only
c. iii only
d. i and ii only
e. i, ii and iii

52. Which of the following half-reactions is correctly balanced?
a. $MnO_4^- → Mn^{2+} + 4H_2O$
b. $Cu + 2Ag^+ → 2Ag + Cu^{2+}$
c. $H_2 + OH^- → 2H_2O$
d. $Pb^{2+} + 2e^- → Pb$
e. $2F^- + 2e^- → F_2$

53. The quantity "one mole" will not be equal to

a. 22.4 L of $H_2(g)$ at STP
b. 6.02×10^{23} carbon atoms
c. 64 grams of $SO_2(g)$
d. 36 grams of H_2O
e. 207 grams of Pb

54. Which statement below is false regarding empirical formulas?
a. The empirical formula for butyne is C_2H_3
b. The empirical formula for ammonia is NH_3
c. The empirical formula of CH_2O is $C_6H_{12}O_6$
d. Ionic compounds are written as empirical formulas
e. The empirical and molecular formulas for methane are the same

55. The percent composition by mass of oxygen in $BaSO_4$ is
a. 233.4%
b. 66.7%
c. 27.4%
d. 58.7%
e. 13.7%

56. How many grams of Fe_2O_3 can be formed from the rusting of 446 grams of Fe according to the reaction: $4Fe + 3O_2 → 2Fe_2O_3$ and excess oxygen?
a. 320 g
b. 223 g
c. 159 g
d. 480 g
e. 640 g

57. Sodium and chlorine react according to the following reaction: $2Na + Cl_2 → 2NaCl$. If the reaction starts with 5.0 moles of Na and 3.0 moles of Cl_2 then which statement below is true?
a. Cl_2 is the excess reagent and 5.0 moles of NaCl will be produced
b. Na is the excess reagent and 2.5 moles of NaCl will be produced
c. There will be an excess of 2.0 moles of Na
d. Na is the limiting reagent and 2.0 moles NaCl will be produced
e. Cl_2 is the excess reagent and 2.0 moles of NaCl will be produced

58. What is the correct mass-action expression for the reaction 2A(aq) + B(aq) ⇌ C(s) + 2D(aq)

a. $K_{eq} = \dfrac{[A]^2[B]}{[C]^3[D]^2}$

b. $K_{eq} = \dfrac{[C]^3[D]^2}{[A]^2[B]^2}$

c. $K_{eq} = \dfrac{[D]^2}{[A]^2[B]}$

d. $K_{eq} = \dfrac{[A]^2[B]}{[D]^2}$

e. $K_{eq} = \dfrac{[C][D]}{[A][B]}$

59. Given the reaction: $3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g)$ + heat energy. Which of the following would drive the equilibrium in the direction opposite to that of the other four choices?
   a. Remove ammonia from the reaction
   b. Increase the temperature of the system
   c. Increase the pressure on the system
   d. Add nitrogen gas
   e. Add hydrogen gas

60. Which of the following demonstrate(s) $\Delta S(-)$?
i. Raking up leaves
ii. Boiling a liquid
iii. Emptying a box of confetti onto the floor
   a. i only
   b. ii only
   c. i and ii only
   d. i and iii only
   e. ii and iii only

61. In which of the following pieces of glassware does a meniscus become of importance?
   a. Watchglass
   b. Burette
   c. Beaker
   d. Flask
   e. funnel

62. If the pressure on a gas is doubled, the volume of the gas will be
   a. Doubled
   b. The same
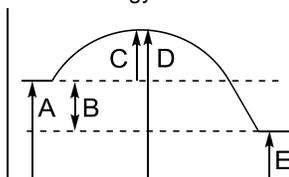   c. Halved
   d. Quartered
   e. quadrupled

63. Which of the following statements about gas collection is false?
   a. Carbon dioxide can be collected by an upward displacement of air
   b. Ammonia can be tested for by placing red litmus paper at the

mouth of the collection glassware
   c. Ammonia can be collected by water displacement
   d. Hydrogen gas can be collected by water displacement
   e. Carbon dioxide can be tested for with a lit match

64. In the diagram shown below, which letter represents the potential energy of the products minus the potential energy of the reactants?

   a. B
   b. D
   c. A
   d. E
   e. C

65. What is the heat of reaction for $A + B \rightarrow F$?

$A + B \rightarrow 2C$ $\quad \Delta H = +150$ kcal
$C \rightarrow 2D + 2E$ $\quad \Delta H = -450$ kcal
$F \rightarrow 4D + 4E$ $\quad \Delta H = +725$ kcal
   a. -1475 kcal
   b. +25 kcal
   c. -1025 kcal
   d. +325 kcal
   e. +300 kcal

66. Molten KBr is allowed to undergo the process of electrolysis. Which reaction occurs at the anode?
   a. $K^+ + e^- \rightarrow K(s)$
   b. $2Br^- \rightarrow Br_2 + 2e^-$
   c. $K(s) \rightarrow K^+ + e^-$
   d. $Br_2 \rightarrow 2Br^- + 2e^-$
   e. $Br_2 + 2e^- \rightarrow 2Br^-$

67. Which will not happen when sodium sulfate is added to a saturated solution of $PbSO_4$ that is at equilibrium? $PbSO_4(s) \rightleftharpoons Pb^{2+}(aq) + SO_4^{2-}(aq)$
   a. The solubility of the lead sulfate will decrease
   b. The concentration of lead ions will decrease
   c. The reaction will shift to the left
   d. The K_{sp} value will change
   e. The equilibrium will shift to consume the increase in sulfate ions

68. What is the voltage of the voltaic cell $Zn|Zn^{2+}||Cu^{2+}|Cu$ at 298 K if $[Zn^{2+}] = 0.2$ M and $[Cu^{2+}] = 4.0$ M?
$Cu^{2+} + 2e^- \rightarrow Cu$ $\quad E^o = +0.34V$

$Zn^{2+} + 2e^- \rightarrow Zn$ $\quad E^o = -0.76$ V
   [Note: $E = E^o - (0.0591/n)(\log Q)$]
   a. +1.10 V
   b. -1.10 V
   c. +1.07 V
   d. +1.14 V
   e. -1.07 V

69. Which of the following molecules has polar bonds but is a nonpolar molecule?
   a. H_2
   b. H_2O
   c. NH_3
   d. $NaCl$
   e. CO_2

70. A titration is set up so that 35.0 mL of 1.0 M NaOH are titrated with 1.5 M HCl. How many milliliters of acid are needed to completely titrate this amount of base?
   a. 15.00 mL
   b. 35.00 mL
   c. 23.33 mL
   d. 58.33 mL
   e. 20.00 mL

71. Which statement is inconsistent with the concept of isotopes of the same element?
   a. Isotopes have the same number of protons
   b. Isotopes have the same atomic number
   c. Isotopes differ in mass number
   d. Isotopes differ in number of neutrons present
   e. Isotopes differ in their nuclear charge

72. Which of the following pairs of substances can be broken down chemically?
   a. Ammonia and iron
   b. Helium and argon
   c. Methane and water
   d. Potassium and lithium
   e. Water and carbon

73. What is the volume of 2.3 moles of an ideal gas at 300 K and a pressure of 1.1 atmospheres?
   a. (2.3)(0.0820)(300) / (1.1)
   b. (1.1) / (2.3)(0.0820)(300)
   c. (2.3)(0.0820) / (300)(1.1)
   d. (300)(0.0820) / (2.3)(1.1)
   e. (2.3)(1.1)(300) / (0.0820)

74. Substance X has three common isotopes: X-48, X-49 and X-51. If the relative abundances of these three isotopes are 42%, 38% and 20% respectively, what is the atomic mass of substance X?
   a. 49.33

b. 48.62
c. 50.67
d. 48.98
e. 49.67

75. Which choice below would affect the rate of reaction in the opposite way from the other four?
a. Cool the reaction down
b. Add a catalyst
c. Decrease the pressure
d. Use larger pieces of solid reactants
e. Decrease the concentration of the reactants

76. One mole of an ideal gas at STP has its temperature changed to 15 $^\circ$C and its pressure changed to 700 torr. What is the new volume of this gas?
a. $(760)(22.4)(288) / (273)(700)$
b. $(273)(700) / (760)(22.4)(288)$
c. $(760)(22.4)(273) / (288)(700)$
d. $(700)(22.4)(287) / (273)(760)$
e. $(760)(1.0)(288) / (273)(700)$

77. Which reaction will occur nonspontaneously?
a. $Au^{3+} + 3e^- \rightarrow Au$
b. $Mg + 2H^+ \rightarrow Mg^{2+} + H_2$
c. $F_2 + 2e^- \rightarrow 2F^-$
d. $Li^+ + e^- \rightarrow Li$
e. $2Na + Cl_2 + 2e^- \rightarrow 2NaCl$

78. As you go from left to right across a period on the periodic table, there is a decrease in
a. First ionization energy
b. Nuclear charge
c. Electronegativity
d. The ability to gain electrons
e. Metallic character

79. Which of the following statements is false?
a. H_2 has just one sigma bond
b. HCl has just one sigma bond
c. H—C≡C—H has four pi bonds and three sigma bonds
d. $CH_2=CH_2$ has five sigma bonds and one pi bond
e. H_2O has two sigma bonds and two lone pairs

80. What is the correct formula for iron(III) sulfate?
a. $FeSO_4$
b. $Fe_2(SO_4)_3$
c. $Fe(SO_4)_3$
d. Fe_3SO_4
e. $Fe_3(SO_4)_2$

81. A solution has a pH of 6.0. What is the concentration of OH$^-$ ions in solution?
a. 6.0×10^{-14} M
b. 1.0×10^{-6} M
c. 1.0×10^{-14} M
d. 6.0×10^{-8} M
e. 1.0×10^{-8} M

82. Which of the following statements about bonding is correct?
a. Only Van der Waals forces exist between polar molecules
b. Dipoles are the result of the equal sharing of electrons
c. Cu(s) is a network covalent solid
d. Hydrogen bonds exist between the molecules of HCl
e. NaCl(aq) has attraction between the molecules and the ions

83. A radioactive substance decays from 100 grams to 6.25 grams in 100 days. What is the half-life of this radioactive substance?
a. 25 days
b. 6.25 days
c. 12.5 days
d. 100 days
e. 50 days

84. Which choice or choices demonstrate amphoterism?
i. $HCl + H_2O \rightarrow H_3O^+ + Cl^-$ and $H_2O + NH_3 \rightarrow OH^- + NH_4^+$
ii. $HS^- + HCl \rightarrow Cl^- + H_2S$ and $HS^- + NH_3 \rightarrow NH_4^+ + S^{2-}$
iii. $HCl + NaOH \rightarrow NaCl + H_2O$ and $NaCl + H_2O \rightarrow HCl + NaOH$
a. i only
b. ii only
c. iii only
d. i and ii only
e. i and iii only

85. Which statement below is incorrect regarding balanced equations?
a. $C + O_2 \rightarrow CO_2$ is balanced and is a synthesis reaction
b. $CaCO_3 \rightarrow CaO + CO_2$ is balanced and is a decomposition reaction
c. $Na + Cl_2 \rightarrow NaCl$ is not balanced but demonstrates a synthesis reaction
d. $KI + Pb(NO_3)_2 \rightarrow PbI_2 + KNO_3$ is balanced and is a single replacement reaction
e. $2H_2O \rightarrow 2H_2 + O_2$ is balanced and demonstrates a redox reaction

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

ANSWERS:

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