Answers and Explanations

1. **The correct answer is (A).** Sodium forms +1 ions in solution, for example NaCl and NaOH.

2. **The correct answer is (C).** Mercury is the only metal which exists as a liquid in its elemental form. Sodium and zinc are typically solids, while nitrogen and helium typically exist in gaseous forms.

3. **The correct answer is (D).** Nitrogen typically forms a -3 oxidation state to form NH_3 (ammonia). No other answer choice forms a -3 oxidation state, thus could not form XH_3.

4. **The correct answer is (C).** The critical point corresponds to the critical temperature and pressure when liquids and gases are no longer distinguishable phases.

5. **The correct answer is (A).** Point A, also known as the triple point, is where a substance coexists as a solid, liquid, and a gas at equilibrium.

6. **The correct answer is (E).** The area of the phase diagram where E is located corresponds to the liquid phase.

7. **The correct answer is (E).** $Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$

8. **The correct answer is (B).** $H_2O(l) + HOCl(aq) \leftrightarrow H_3O^+(aq) + OCl^-(aq)$

9. **The correct answer is (D).** Noble gases, i.e. Xe, do no react.

10. **The correct answer is (B).** In $CHCl_3$ there are four ligands and no unpaired electrons, thus $CHCl_3$ is tetrahedral.

11. **The correct answer is (A).** Carbon forms a double bond with each oxygen atom so there are no unpaired electrons.

12. **The correct answer is (E).** There are five ligands that want to maximize the space between them, forming a trigonal-bipyramidal geometry.

13. **The correct answer is (D).** In ammonia there are three ligands and one pair of nonbonding electrons.

14. **The correct answer is (C).** Octahedral complexes form when there are six ligands.

15. **The correct answer is (A).** HCl acts as an acid and NaOH acts as a base to produce NaCl (*aq*) and H_2O.

16. **The correct answer is (C).** A hydrocarbon burning in oxygen is a combustion reaction. The products are always CO_2 and H_2O.

17. **The correct answer is (B).** The products are two alpha-particles ($^4He_2$). This is the initial fusion reaction that occurs in a hydrogen bomb.

18. **The correct answer is (D).** The products are PbI_2 (*s*) + $2NaNO_3$ (*aq*). Because PbI_2 precipitates from solution, this is a precipitation reaction.

19. **The correct answer is (A).** Water has the highest boiling point as a result of hydrogen bonding. All other species listed are gases at STP.

20. **The correct answer is (D).** The molecular weight of H_2Te is 129.6 g/mol. Although increasing molecular weight usually results in higher boiling points, stronger intermolecular forces, like those seen in water, outweigh the factor of molecular weight.

21. **The correct answer is (A).** See explanation to question #19.

22. **The correct answer is (D).** The rate law given shows the concentration of A raised to the second power, therefore it is second order with respect to reactant A. In addition, the concentration of B is raised to the first power, thus the reaction is first order with respect to B. The overall order of a reaction is the sum of the orders with respect to the reactants. Therefore, the order is 3.

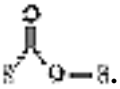
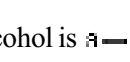
23. **The correct answer is (C).** The rate law shows that the rate of reaction is second order with respect to reactant A. Doubling the concentration of reactant A results in quadrupling the rate of reaction.

24. **The correct answer is (B).** An exothermic reaction produces heat, thus adding heat shifts the reaction to the reactants. Temperature has no affect on reaction rate.

25. **The correct answer is (C).** The element with atomic number 20 is Calcium (Ca). Elements in the second row of the periodic table form ions with a +2 oxidation state in order to have a noble electron configuration.

26. **The correct answer is (E).** Nitrogen may exist as gaseous N_2, which comprises 80% of air. Lithium, phosphorous, vanadium, and aluminum exist as solids in nature.

27. **The correct answer is (C).** The element with the electron configuration shown is flourine. Flourine forms a -1 oxidation state, while calcium forms a +2 oxidation state. In order to form a neutral compound, one calcium and two fluorines are necessary.

28. **The correct answer is (C).** An ester is  . A carboxylic acid is  . An alcohol is . An amine is  .

29. **The correct answer is (B).** The electron configuration of tin, Sn, is $[Kr]5s^25d^{10}6p^2$. To describe one of the 6p electrons, n is 6, l is 1 (the p orbital corresponds to l = 1), m_l can be -1, 0 or 1, and ms is either $+\frac{1}{2}$ or $-\frac{1}{2}$.

30. **The correct answer is (B).** The electron configuration of tin, Sn, is $[Kr]5s^25d^{10}6p^2$. To describe one of the 6p electrons, n is 6, l is 1 (the p orbital corresponds to l = 1), m_l can be -1, 0 or 1, and ms is either $+\frac{1}{2}$ or $-\frac{1}{2}$.

31. **The correct answer is (A).** Remember, losing electrons is oxidation and gaining electrons is reduction. In the cell, zinc is oxidized, so rewrite the given information as:

$Cu^{2+} + 2e^- \rightarrow Cu \quad E^o = 0.34\ V$
$Zn \rightarrow Zn^{2+} + 2e^- \quad E^o = +0.76\ V$

$Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu \quad E^o = +1.1\ V$

and sum the reactions to get the overall reaction and the value of the standard emf.

32. **The correct answer is (E).** The salt bridge allows for the migration of ions from one half-cell to the other. The salt bridge contains inherently inert salts, so no reactions would take place within the salt bridge.

33. **The correct answer is (E).** Alkali metals are the Group 1A elements, i.e. Li, Na, K, etc. $^{40}X_{19}$ corresponds to potassium, K.

34. **The correct answer is (B).** The balanced reaction is $2NH_3 \rightarrow N_2 + 3H_2$. Thus, two moles of NH_3 would produce one mole of N_2. One mole is 22.4 L at STP.

35. **The correct answer is (D).** A homogenous mixture is one in which the composition of the mixture is uniform throughout. Oil does not dissolve in water, thus the composition would not be uniform.

36. **The correct answer is (A).** Addition of a product, H_2O, will shift the equilibrium to the reactants.

37. **The correct answer is (D).** Heat flows from the water to the surroundings as the temperature of the water drops to the temperature of the freezer, hence a decrease in energy. When the water begins to freeze, it changes to a more ordered system, thus the entropy decreases.

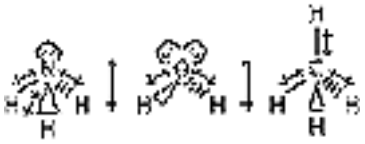
38. **The correct answer is (C).** The balanced equation is $2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$. Three moles of oxygen produce two moles of water.

39. **The correct answer is (B).** The formula of sodium sulfate is $(Na)_2SO_4$. Thus, complete ionization yields two sodium ions and one sulfate ion.

40. **The correct answer is (E).** The balanced equation is $3H_2S(aq) + 2MnO_4^-(aq) \rightarrow 3S(s) + 2MnO_2(s) + 2H_2O(l) + 2OH^-(aq)$

41. **The correct answer is (A).** The reaction is HCl + NaOH → NaCl + H_2O. Using the relationship $M_1V_1 = M_2V_2$, (2L)(0.03M) = (0.2M)(V_2). Hence, V_2, the volume of NaOH necessary is 0.3L.

42. **The correct answer is (D).**



43. **The correct answer is (D).** The electron configuration of Mn is $[Ar]4s^23d^5$. According to Hund's rule, each electron in the d shell would be unpaired, while each electron in the s shell would be paired. Thus there are five unpaired electrons.

44. **The correct answer is (E).** Within a row, atomic size decreases as the atomic number increase, but ionic size increases as the atomic number increases. Both atomic and ionic radii increase as the principal quantum number, n, increases.

45. **The correct answer is (C).** A distillation is the best way to separate two miscible liquids with a large difference in boiling point. Fractional distillation is useful for separating liquids with similar boiling points, chromatography is not used to separate liquids, filtration is useful to separate solids and liquids, and extraction is useful for separating non-miscible liquids.

46. **The correct answer is (A).** S begins as +4 because O is -2 and the overall charge of the ion is -2. S becomes +6 because an additional O is added to the molecule. Fe begins as +3 and becomes +2 because the oxidation number of an individual ion is the same as its charge.

47. **The correct answer is (E).** Equilibrium constants are expressed as products divided by reactants. As a rule, only liquids and gases are included in the expression.

48. **The correct answer is (B).** Following the rule, "like dissolves like", water is a very polar molecule, so other very polar molecules will dissolve in water. Hydrochloric acid (HCl) is the most polar compound of the choices given. Methane (CH_4), Toluene ($C_6H_5CH_3$), Octanol ($CH_3(CH_2)_7OH$), and ethyl ether ($(CH_3CH_2)_2O$) are not very polar species.

49. **The correct answer is (E).** Freezing point is a colligative property and solutes in water result in freezing point depression. The more ions in solution, the more the freezing point will be depressed. A 2 molal solution of H_3PO_4 will have the highest concentration of ions ($H_3PO_4 \rightarrow 3H^+ + PO_4^{3-}$), and thus has the lowest freezing point.

50. **The correct answer is (C).** The balanced combustion reaction is: $CH_4 + O_2 \rightarrow CO_2 + 2H_2O$. Three moles of methane would produce twice as many moles of water, thus six moles of water are produced.

51. **The correct answer is(C).** Carbon with four single bonds hybridizes as sp^3.

52. **The correct answer is (E).** C_1, C_7, and O_1 are sp^2 hybridized, and O_2 is sp^3 hybridized.

53. **The correct answer is (A).** In nuclear reactions, the mass number must be balanced.

54. **The correct answer is (E).** For elements with the same principal quantum number, electronegativity increases from left to right across the periodic table.

55. **The correct answer is (B).** Entropy is a measure of disorder, and higher disorder is favored.

56. **The correct answer is (B).** Summing the reactions given results in the reaction in question. To determine ΔH for the reaction given, simply sum the ΔH of reaction (i) and reaction (ii).

57. **The correct answer is (E).** The temperature should be read from the bottom of the meniscus. The temperature to the tenths place can be read, and the hundredths place should be estimated to have the correct number of significant figures.

58. The correct answer is (D). Triple bonds are inherently stronger than single or double bonds, and would require the most energy to cleave.

59. The correct answer is (C). Density = mass/volume and PV = nRT. Substituting V = nRT/P into the density expression, we get density = mass (P/(nRT). Molecular weight (MW) is simply mass/n, so density = (MW*P)/(RT), which equals 0.33 g/L.

60. The correct answer is (B). Chlorine-37 has an atomic number of 17 and a mass number of 37. The number of protons corresponds to the atomic number and the number of neutrons is the difference between the atomic number and the mass number.

61. The correct answer is (C). Ionization is a measurement of the energy necessary to remove an electron from an atom. Ionization energy increases going across the periodic table from left to right, and going up a column. Neither F nor Ne would want to lose electrons (F wants to gain electrons and Ne already has a noble electron configuration) and would have very large ionization energies. Going down group 1A the ionization energy decreases from Li to Na to K.

62. The correct answer is (C). Spontaneous reactions have a negative ΔG. ΔH is negative for an exothermic reaction. The entropy of the system decreases (a solid is created from a liquid and a gas), so ΔS is negative.

63. The correct answer is (C). Allotropes are elemental substances that occur in more than one form.

64. The correct answer is (D). Proper scientific notation only uses the "ones" place and any remaining significant digits are after the decimal point.

65. The correct answer is (A). Phosphorous, with an atomic number of 15 and an atomic mass of 31, has 16 neutrons, not 31.

66. The correct answer is (E). The concentration of H^+ is 1.0 because HBr dissociates completely. pH = -log[H^+], or pH = -log 1 = 0. Because pOH = 14-pH, pOH = 14.

67. The correct answer is (C). Removing PCl_3 as it is formed would shift the equilibrium to the products. Each of the other choices results in the equilibrium shifting to the reactants.

68. The correct answer is (D). Atomic fission is defined as the splitting of a heavy nucleus into nuclei of lighter elements. Atomic fusion is the fusion of two lights elements into a heavier element.

69. The correct answer is (B). First, convert degrees Farhenheit to degrees Celsius using $^oF = 1.8(^oC) + 32$. To convert from degrees Celsius to Kelvin, add 273.

70. The correct answer is (B). Organic molecules are compounds containing carbon atoms bonded to hydrogen. Choice (B) is an amine.

71. The correct answer is (D). Changing the temperature is the only thing that will affect the value of an equlibrium constant.

72. The correct answer is (C). The overall nuclear reaction is:

$$^9Be_4 + {}^4He_2 \rightarrow {}^{12}C_6 + {}^1n_0$$

73. The correct answer is (A). The molecular weight of H2O is 18 g/mol, thus there is 0.5 moles of water. One mole is 6.02×10^{23} atoms, so half of a mole is 3.01×10^{23}.

74. The correct answer is (E). If there are 12.04×10^{23} atoms, and there are 6.02×10^{23} atoms per mole, there are two moles of H_2 present. There are 22.4 liters of gas per mole present at STP, so there are 44.8L of H_2O present.

75. The correct answer is (E). Colligative properties are the properties of a solution that depends on the nature of the solvent and the number of solute particles present. Boiling point is affected by the number of solute particles in a solvent.

76. The correct answer is (D). The oxidation number of H is +1 and the oxidation number of F is -1, thus Si must be +4 to balance the charge.

77. The correct answer is (D). The expression for K_p is $P_{NH3}*P_{HCl}$. (Solids are not part of equilibrium expressions.) Thus, $K_p = (1.2)(2) = 2.4$

78. The correct answer is (B). Magnesium has an atomic number of 12 and its electron configuration is $[Ne]3s^2$.

79. The correct answer is (A). There are eight points in the unit cell on a corner, which count as 1/8 of an atom each. In addition, there is one point within the body of the unit cell. Thus, there are two Vanadium atoms per unit cell.

80. The correct answer is (B). Dissolving acid in water is an exothermic process.