PRACTICE TEST 2: MULTIPLE-CHOICE ANSWER KEY

1. B
2. A
3. B
4. D
5. A
6. D
7. D
8. B
9. B
10. B
11. C
12. A
13. B
14. D
15. A
16. B
17. D
18. C
19. B
20. A
21. A
22. C
23. C
24. D
25. D
26. B
27. D
28. C
29. A
30. A
31. B
32. C
33. D
34. C
35. A
36. D
37. C
38. A
39. D
40. D
41. C
42. D
43. D
44. B
45. A
46. A
47. C
48. C
49. A
50. A
51. C
52. C
53. B
54. D
55. B
56. D
57. C
58. B
59. A
60. A

Section I—Multiple-Choice Answers and Explanations

1. B

During a phase change, ΔG = 0. Plugging that into the ΔG = ΔH–TΔS equation, you get $0 = \frac{23.9 \text{ kJ}}{\text{mol}} - (239 \text{ K})(\Delta S)$. Solving that yields $\Delta S = \frac{0.10 \text{ kJ}}{\text{mol} \times \text{K}}$, which converted to Joules is $\frac{100 \text{ J}}{\text{mol} \times \text{K}}$.

2. A

As C_6H_6 has the higher boiling point, it must have stronger IMFs. This also means it has a lower vapor pressure. As C_6H_6 is completely nonpolar, the only way it could have stronger IMFs than C_2H_5OH is if the LDFs in C_6H_6 are significantly stronger than any IMFs present in C_2H_5OH. Stronger LDFs = a more polarizable electron cloud.

3. B

For oxoacids, the more electronegative the halogen is, the stronger the acid is due to the fact that the electrons are pulled away from the O-H bond, causing the H^+ to ionize more frequently. So, any oxoacid containing Cl is a stronger acid than one containing Br. Between the two acids containing Cl, the more oxygens that are present, the lower the total charge is on each oxygen in the conjugate base. That means the oxygens in ClO_2^- are less likely than the oxygen in ClO^- to attract protons, which in turn means the protons are more likely to stay ionized in $HClO_2$, creating a stronger acid.

4. D

From the graph, you can see that the most common isotope of zirconium has an atomic mass of 90. Atomic mass is equal to the number of protons plus the number of neutrons, and all zirconium atoms have 40 protons. 90 – 40 = 50 neutrons.

5. A

Gases deviate from ideal behavior when their IMFs are significant enough to affect their behavior. When IMFs cause gas molecules to attract each other, that means they will hit the sides of the container less often and decrease the pressure. In this case, H_2O has the strongest IMFs due to hydrogen bonding, and thus H_2O molecules are most likely to deviate from ideal behavior.

6. D

Chromium goes from +6 to +3, meaning it gains electrons and is reduced. Fe goes from +2 to +3, meaning it loses electrons and it is oxidized.

7. D

The chromium goes from an oxidation state of +6 to +3, and there are two chromium atoms. That means chromium gains a total of six electrons. The iron only loses one electron every time it goes from an oxidation state of +2 to +3, and thus it must happen six times for the charge to balance.

8. B

When losing electrons, transition metals will lose their outermost s electrons first, followed by their outermost d electrons. The electron configuration of an iron atom is $[Ar]4s^2 3d^6$, so after losing three electrons it will be $[Ar]3d^5$.

9. B

XeF_4 has a molecular geometry that is square planar, and because all of the terminal atoms are identical it will have no dipole moment. All of the other options have asymmetrical geometries.

10. B

Ionic substances such as NaCl do not conduct electricity in their solid form, but do when melted and/or dissolved in water.

11. C

Beer's law states that A = abc, where the small a is molar absorptivity. When plotting Absorbance on the y-axis and concentration on the x-axis, the slope of the line would be equal to ab. As b = 1.0 cm, the slope of the line is equal to the molar absorptivity constant. Use data from two points:

$$\frac{(0.025 - 0.013)}{(0.050 - 0.025)} = \frac{1.2 \times 10^{-1}}{2.5 \times 10^{-2}} = 0.5 \times 10^{1} = 5.0\ M^{-1}cm^{-1}.$$

12. A

N-doping involves injecting an element with five valence electrons into an existing lattice, usually one made of silicon. In this diagram, the phosphorus atom replaces a silicon atom, but with five valence electrons that extra electron is free to move throughout the lattice.

13. B

$$(0.10\ M\ \mathrm{NaOH})(0.020\ \mathrm{L}) = 0.0020\ \mathrm{mol\ OH^-} \times \frac{1\ \mathrm{mol\ H_2C_2O_4}}{2\ \mathrm{mol\ NaOH}} = 0.0010\ \mathrm{mol\ H_2C_2O_4}$$

$$\frac{0.0010\ \mathrm{mol\ H_2C_2O_4}}{0.020\ \mathrm{L}} = \frac{1.0 \times 10^{-3}\ \mathrm{mol}}{2.0 \times 10^{-2}\ \mathrm{L}} = 0.50 \times 10^{-1}\ M = 0.050\ M.$$

14. D

At a volume of 20 mL, the OH^- has fully reacted with the $H_2C_2O_4$, removing all of its protons. Other than water, the only species present in significant concentrations at that point is the $C_2O_4^{2-}$.

15. A

Below a pH of 9.1, the predominant form of the indicator will be its protonated state, HAc. Above 9.1, there will be more of the conjugate base, Ac^-.

16. B

The strength of the acid is irrelevant. H_2SO_4 has the same number of protons as $H_2C_2O_4$, and thus it will require the same amount of base to fully neutralize.

17. D

The voltage of the cell is dependent on how close it is to equilibrium. The closer a cell is to equilibrium, the lower the voltage will become. Because all cells with a positive E_{cell} are favored, K is very large. In this case, $Q = \frac{[Fe^{2+}]}{[Ag^+]^2}$. If water is added, it will decrease the concentration of both Ag^+ and Fe^{2+}. However, doing so affects the value of the denominator more because it is squared. Consequently, Q will end up getting bigger, bringing the reaction closer to equilibrium and decreasing the overall voltage.

18. C

Adding a catalyst reduces the activation energy for the reaction. This means a larger percentage of collisions will have enough energy to successfully react.

19. B

The best way to solve this problem is by using an ICE chart. Start by entering the initial pressure values, as well as the change in each (determined by the coefficients in the balanced equation).

$$2\ CO(g) + 2\ NO(g) \rightarrow 2\ CO_2(g) + N_2(g)$$

I	2.0	1.0	0	0
C	$-2x$	$-2x$	$+2x$	$+x$
E				

The NO limits, given that it reacts at the same rate as the CO, but start with half as much of it. So, 1.0 – 2x = 0, and thus x =0.50. Using that, finish the chart.

$$2\ CO(g) + 2\ NO(g) \rightarrow 2\ CO_2(g) + N_2(g)$$

I	2.0	1.0	0	0
C	$-2x$	$-2x$	$+2x$	$+x$
E	1.0	0	1.0	0.50

$$1.0 + 1.0 + 0.5 = 2.5 \text{ atm}$$

20. A

The oxygen atom has a configuration of $1s^2 2s^2 2p^4$. The oxide ion would be $1s^2 2s^2 2p^6$. So, there will be two additional electrons in the 2p subshells, which corresponds with the rightmost peak. That peak thus grows taller.

21. A

The bond length always corresponds to the point where the potential bond energy (a balance of the attraction and repulsion forces between the two atoms) is at its minimum value.

22. C

The IMFs between HF molecules are hydrogen bonds, which are very strong dipoles created due to the high electronegativity value of fluorine. No other hydrogen halide exhibits hydrogen bonding, and thus they would have weaker intermolecular forces (and lower boiling points) than HF.

23. C

Weak acids resist changes in pH more effectively than strong acids because so many molecules of weak acid are undissociated in solution. The base must cause those molecules to dissociate before affecting the pH significantly.

24. D

Using $M_1V_1 = M_2V_2$, you can calculate the amount of stock solution needed. $(12.0)V_1 = (4.0)(100.0)$, so $V_1 = 33.3$ mL. When making solutions, always add acid to water (in order to more effectively absorb the heat of the exothermic reaction).

25. D

When calculating enthalpy, the total energy change in the reaction is always calculated by the following:

Bonds broken (reactants) – Bonds formed (products)

The more negative this value is, the more energy that was released in the bond formation of the products compared to the amount of energy necessary to break the bonds in the reactants.

26. B

There are two moles of gaseous reactants, and four moles of gaseous products. That means the disorder increased, yielding a positive value for ΔS.

27. D

The addition of a catalyst speeds up the reaction but will not affect the enthalpy or the entropy values.

28. C

2.0 moles of CH_4 would react with 3.0 moles of H_2O, leaving 1.0 mole left. It would also create 6.0 moles of H_2 and 2.0 moles of CO.

29. A

When the listed amounts react, the O_2 will be the limiting reactant, as it is used up twice as quickly (this is determined by the coefficients in the reaction). Therefore,

So: $2.0 \text{ mol } O_2 \times \dfrac{1 \text{ mol}_{rxn}}{2.0 \text{ mol } O_2} \times \dfrac{-890 \text{ kJ}}{1 \text{ mol}_{rxn}} = -890 \text{ kJ}$

That gives the magnitude of the energy change, and the negative sign means heat will be released.

30. A

London dispersion forces are created by temporary dipoles due to the constant motion of electrons in an atom or molecule.

31. B

The higher the temperature of any substance, the larger the range of velocities the molecules of that substance can have, and thus the more disorder the substance can have. A Maxwell-Boltzmann diagram represents this in a graphical form.

32. C

When equimolar amounts of an acid and its conjugate base are mixed, the pH of the buffer which is created will be the same as the pK_a of the weak acid. The pK_a for $HC_2H_3O_2$ is between 4 and 5.

33. D

Distillation involves the boiling off of substances with different boiling points. The other three compounds are all ionic, meaning that in solution they are free ions. If one were to boil off all of the N_2H_4 and the water, the remaining ions would all mix together to form multiple precipitates. However, by heating the solution to a boiling point greater than that of N_2H_4 and lower than that of water, the N_2H_4 can be collected in a separate flask.

34. C

At identical temperatures, the gases would all have identical amounts of kinetic energy. In order for that to happen, the gas with the lowest mass (H_2) would have to have the highest average velocity, and the gas with the highest mass (F_2) would have to have the lowest average velocity.

35. A

Like dissolves like, so ionic substances dissolve best in ionic compounds, eliminating (B). Both (C) and (D) share an ion with $MgCl_2$. Via the common ion effect and Le Châtelier's principle, that would reduce the solubility of the $MgCl_2$ in those solutions. The best choice is (A).

36. D

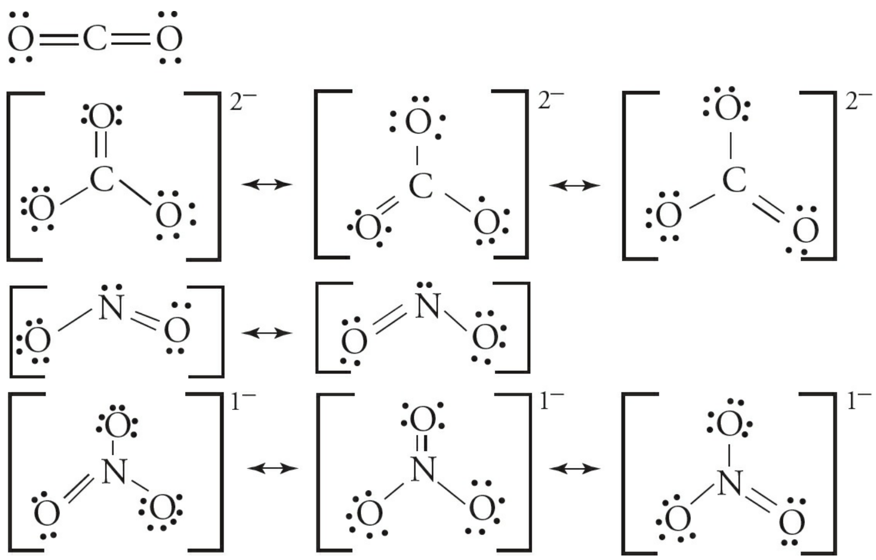
The outermost s-block electrons in a transition metal tend to be lost before the d-block electrons. Additionally, the other options do not accurately describe the properties of transition metals.

37. C

Adding or removing a solid would not cause any equilibrium shift. Decreasing the concentration of the Fe^{2+} causes a shift to the right, which would increase the potential of the cell.

38. A

The following Lewis structures are necessary to answer questions 38–41:



CO_2 has a bond order of 2, which exceeds the order of the other structures. Remember that a higher bond order corresponds with shorter and stronger bonds.

39. D

Except for CO_2, the other molecules all display resonance.

40. D

All three of those structures have three electron domains, and thus sp^2 hybridization.

41. C

The bond angle of NO_2^- would be less than that of NO_3^- or CO_3^{2-} because the unbonded pair of electrons on the nitrogen atom reduces the overall bond angle.

42. D

Even if this were true, any pathways that become available at higher temperatures would be less likely to be taken than the original pathway.

43. D

The Na^+ cations would be attracted to the negative (oxygen) end of the water molecules and the Cl^- anions would be attracted to the positive (hydrogen) end. Additionally, Na^+ ions are smaller than Cl^- ions because they have less-filled energy levels.

44. B

In this case, the pH is greater than the pK_a. This means that there will be more conjugate base present in solution than the original acid. The conjugate base of HNO_2 is NO_2^-.

45. A

Combustion reactions are irreversible, while the other reactions are examples of acid-base, dissolution, and oxidation-reduction, all of which are reversible in this case.

46. A

Equilibrium is always products over reactants, and coefficients in a balanced equilibrium reaction become exponents in the equilibrium expression.

47. C

The concentration of the H_2S will decrease exponentially until it reaches a constant value. The concentrations of the two products will increase exponentially (the H_2 twice as quickly as the S_2) until reaching equilibrium.

48. C

Increasing the pressure causes a shift toward the side with fewer gas molecules—in this case, a shift to the left. This means the reverse reaction rate increases while the forward reaction rate decreases.

49. A

The reaction will progress until $Q = K_c$. If $Q < K_c$, the numerator of the expression (the products) will continue to increase while the denominator (the reactant) decreases until equilibrium is established.

50. A

If the temperature is constant, then the equilibrium constant K is unchanged. Via $\Delta G = -RT \ln K$, if K and T are both constant, then so is the value for ΔG.

51. C

An ionic substance would dissolve in water, and a nonpolar covalent substance would have a low melting point. A metallic substance would be a good conductor. The only type of bonding that meets all the criteria is covalent network bonding.

52. C

Light contains energy (via $E = hv$), and that energy can be used to cause a reaction.

53. B

In 200 seconds, half of the original sample decayed. In another 200 seconds, half of the remaining sample decayed. This demonstrates a first order reaction.

54. D

O_x has 6 valence electrons and 7 assigned electrons: $6 - 7 = -1$. Both O_y and the N atoms have the same number of valence and assigned electrons, making their formal charges zero.

55. B

The strength of an atom's magnetic moment increases with an increase in the number of unpaired electrons. Nitrogen has the most unpaired electrons (3), and thus the strongest magnetic moment.

56. D

Sulfur is the only element with an empty d-block in its outermost energy level, and is thus the only atom of the four that can form an expanded octet.

57. C

Neon has six electrons in its subshell with the lowest ionization energy (2p), and only two electrons in the other two subshells (1s and 2s). This means the 2p peak will be three times higher than the other two peaks.

58. B

The amount of matter is equal on both sides of the reaction. None of the other options are supported by the diagram.

59. A

The overall rate law is always equal to the rate law of the slowest elementary step. The rate law of any elementary step can be determined using the coefficients of the reactants in that step.

60. A

Reactions with high activation energies that do not proceed at a measurable rate are considered to be under kinetic control—that is, their rate of progress is based on kinetics instead of thermodynamics.

Section II—Free-Response Answers and Explanations

1.

(a)