Chem 171-2-3: Final Exam Review

Multiple Choice Problems

1. What is the molar mass of barium perchlorate, \( \text{Ba(ClO}_4\text{)}_2 \)?
   a. 189.90 g/mol  
   b. 240.24 g/mol  
   c. 272.24 g/mol  
   d. 304.24 g/mol  
   e. 336.20 g/mol  
   f. 473.37 g/mol

2. A sample of copper weighing 6.93 g contains how many moles of copper atoms?
   a. 9.17 mol  
   b. 0.0645 mol  
   c. 0.917 mol  
   d. 1.09 mol  
   e. 6.56 \times 10^{22} \text{ mol}  
   f. 0.109 mol

3. Carbon disulfide is a liquid that can be used in the production of rayon and cellophane. It is manufactured from methane and elemental sulfur according to the following chemical equation:
   \[ \text{CH}_4 (g) + 4 \text{ S (s)} \rightarrow \text{CS}_2 (l) + 2 \text{ H}_2\text{S (g)} \]
   How many moles of \( \text{CS}_2 \) can be formed by the complete reaction of 10.6 mol of \( \text{S} \)?
   a. 1 mol  
   b. 10.6 mol  
   c. 2.65 mol  
   d. 42.4 mol  
   e. 4 mol  
   f. 2 mol

4. Which of the following aqueous solutions would you use in a qualitative chemical test to identify a solution of \( \text{Ba(OH)}_2 \)?
   a. \( \text{AgNO}_3 \)  
   b. \( \text{BaCl}_2 \)  
   c. \( \text{HNO}_3 \)  
   d. \( \text{H}_2\text{SO}_4 \)  
   e. \( \text{NaOH} \)  
   f. \( \text{NH}_3 \)

5. What results would you expect from a litmus test of a solution of \( \text{Ba(OH)}_2 \)?
   a. red litmus paper will turn blue  
   b. blue litmus paper will turn red  
   c. there will be no change with either red or blue litmus paper  
   d. both red and blue litmus paper will change color

6. A sample of tungsten occupies a volume of 5.38 cm\(^3\). What is the mass, in grams, of this sample of tungsten? (for tungsten, density = 19.35 g/cm\(^3\))
   a. 104 g  
   b. 0.278 g  
   c. 3.60 g  
   d. 19.4 g  
   e. 5.38 g  
   f. 28.9 g

7. A compound has a molecular formula of \( \text{C}_{12}\text{H}_{24}\text{O}_6 \). What is this compound's empirical formula?
   a. \( \text{CHO} \)  
   b. \( \text{C}_6\text{H}_{12}\text{O}_3 \)  
   c. \( \text{C}_2\text{H}_4\text{O} \)  
   d. \( \text{C}_{12}\text{H}_{25}\text{O}_6 \)  
   e. \( \text{C}_4\text{H}_8\text{O}_2 \)  
   f. \( \text{CH}_2\text{O} \)

8. A non-metallic element X forms a compound with potassium that has the formula \( \text{K}_2\text{X} \). Which one of the following elements could be X?
   a. boron  
   b. antimony  
   c. silicon  
   d. neon  
   e. chlorine  
   f. selenium

9. What is the mass, in grams, of potassium in 12.5 g of \( \text{K}_2\text{Cr}_2\text{O}_7 \) (molar mass = 294.40 g/mol)?
   a. 1.66 g  
   b. 78.2 g  
   c. 8.80 g  
   d. 3.32 g  
   e. 0.0424 g  
   f. 12.5 g

10. Calculate the mass percent nitrogen in \( \text{(NH}_4\text{)}_2\text{CO}_3 \) (molar mass = 96.09 g/mol).
    a. 29.1 %  
    b. 35.9 %  
    c. 17.9 %  
    d. 0.292 %  
    e. 14.6 %  
    f. 96.1 %
11. Consider the following balanced chemical equation:
\[ 3 \text{Mg} (s) + \text{B}_2\text{O}_3 (s) \rightarrow 2 \text{B} (s) + 3 \text{MgO} (s) \]
What mass, in grams, of magnesium oxide are formed when 100.0 g of \( \text{B}_2\text{O}_3 \) is allowed to react to completion with excess magnesium?

a. 57.90 g  
   c. 115.8 g  
   e. 40.31 g  

b. 173.7 g  
   d. 100.0 g  
   f. 19.30 g

12. Which one of the following compounds is not a strong electrolyte?

a. KOH  
   c. Na\(_2\)CO\(_3\)  
   e. HCl  

b. CuSO\(_4\)  
   d. HNO\(_2\)  
   f. NH\(_4\)Br

13. A gas mixture is composed of 1.00 mol of He, 2.00 mol of Ar, and 2.00 mol Kr. At STP, the partial pressure of He is:

a. 152 torr  
   c. 1.00 atm  
   e. 0.200  

b. 22.4 L/mol  
   d. 4.00 g/mol  
   f. 5.00 atm

14. Which of the following substances has the smallest density at 300 K and 1 atm?

a. C (s)  
   c. NH\(_3\) (g)  
   e. H\(_2\)O (l)  

b. Ar (g)  
   d. SF\(_6\) (g)  
   f. Xe (g)

15. What kind of reactant can convert HSO\(_3\)\(^-\) (aq) to SO\(_3\)\(^2-\) (aq)?

a. oxidizing agent  
   c. reducing agent  
   e. acid  

b. base  
   d. precipitating agent  
   f. none of the above

16. For an ideal gas at constant temperature, the number of molecules is

a. inversely proportional to P x V  
   c. inversely proportional to V  

b. directly proportional to P x V  
   d. directly proportional to R

17. Compared to the rate of effusion of N\(_2\) (g), the rate of effusion of SF\(_6\) (g) is:

a. 5.21 times faster  
   c. 2.28 times faster  
   e. 27.2 times faster  

b. 5.21 times slower  
   d. 2.28 times slower  
   f. 27.2 times slower

18. When 68.3 mg of Li\(_2\)C\(_2\)O\(_4\) (molar mass = 101.90 g/mol) dissolves in 200.0 mL of water, the [Li\(^+\) (aq)] is

a. 6.70 mol/L  
   c. 0.00335 mol/L  
   e. 0.0346 mol/L  

b. 0.00742 mol/L  
   d. 0.00335 mol/L  
   f. 0.00670 mol/L

19. A gas mixture contains 3.00 atm of H\(_2\) and 1.00 atm of O\(_2\) in a 1.00 L vessel at 400K. If the mixture burns to form water while the temperature is held at 400K, what is the partial pressure of H\(_2\)O?

a. 5.00 atm  
   c. 2.00 atm  
   e. 1.00 atm  

b. 3.00 atm  
   d. 4.00 atm  
   f. 0.500 atm

20. The energy of a photon of light is ______ proportional to its frequency and ______ proportional to its wavelength.

a. directly, directly  
   b. inversely, inversely  
   c. inversely, directly  
   d. directly, inversely
21. Aluminum metal reacts with chlorine according to the following chemical equation:
\[ 2 \text{Al} (s) + 3 \text{Cl}_2 (g) \rightarrow 2 \text{AlCl}_3 (s); \Delta H = -1408 \text{kJ} \]
How much heat (in kJ) will be produced when 5.00 g of Al react?

a. –130 kJ  

b. +130 kJ  

c. –261 kJ  

d. +261 kJ  

e. –1408 kJ  

f. –704 kJ

22. The probability of finding an electron at a given point in space is given by the value of ______ at that point.

a. \( \frac{hc}{\lambda} \)  

b. \( \gamma \)  

c. \( \gamma^2 \)  

d. \( l \)

23. Which set of quantum numbers cannot be correct?

a. \( n = 2, l = 0, m_l = 0, m_s = +1/2 \)  

b. \( n = 3, l = 1, m_l = -1, m_s = -1/2 \)

c. \( n = 2, l = 1, m_l = -1, m_s = +1/2 \)

d. \( n = 1, l = 1, m_l = 1, m_s = +1/2 \)

24. Which one of the following orbitals can hold two electrons?

a. \( 2p_x \)  

b. \( 3s \)  

c. \( 4d_{xy} \)  

d. all of the above

25. Rank the following elements in order of **DECREASING** atomic radius: Mg, Na, P, Si, Ar

a. Mg, Na, P, Si, Ar  

b. Ar, Si, P, Na, Mg  

c. Si, P, Ar, Na, Mg  

d. Na, Mg, Si, P, Ar

26. Element \( X \) reacts with chlorine to form a compound with the formula \( X \text{Cl}_2 \). The oxide of this element is basic. Element \( X \) is:

a. Rb  

b. Ca  

c. Al  

d. P

27. The elements with the lowest first ionization energies belong to what group?

a. alkali metals  

b. noble gases  

c. halogens  

d. alkaline earth metals

28. Which one of the following metals is most likely to form cations of several different charges?

a. Al  

b. Cs  

c. Co  

d. Ca

29. Crystalline solids:

a. have highly ordered structures  

b. are usually very soft  

c. exist only at high temperatures.

30. In which one of the following substances is the kinetic energy greatest relative to the intermolecular forces of attraction?

a. \( \text{H}_2\text{O} \text{ (l)} \)  

b. \( \text{NaCl} \text{ (s)} \)  

c. \( \text{CO} \text{ (g)} \)  

d. \( \text{CH}_3\text{OH} \text{ (l)} \)

31. Which one of the following compounds will have hydrogen bonding as one of its intermolecular forces?

a. \( \text{H}_2\text{S} \)  

b. \( \text{SiH}_4 \)  

c. \( \text{HCl} \)  

d. \( \text{NH}_3 \)

32. What is the predominant intermolecular force in \( \text{CBr}_4 \)?

a. London dispersion forces  

b. ion-dipole forces  

c. ionic bonding  

d. dipole-dipole forces

33. Which type of intermolecular force is the strongest?

a. London dispersion force  

b. dipole-dipole force  

c. hydrogen bonding
34. As the strengths of intermolecular attraction increase, the boiling point of a liquid will
   a. increase  b. decrease  c. remain constant

35. The direct conversion of a solid to a gas is called
   a. fusion  b. vaporization  c. condensation  d. sublimation

36. For a given substance, which is generally larger?
   a. $\Delta H^\circ_{\text{fus}}$  b. $\Delta H^\circ_{\text{vap}}$  c. $\Delta H^\circ_{\text{sub}}$

37. Which one of the following statements about phase diagrams ($P$ vs $T$) is true?
   a. the critical point is that beyond which gas and solid are indistinguishable
   b. triple point is that at which solid, liquid, and gas are in equilibrium
   c. solid is generally found at high $T$ and low $P$
   d. liquid is generally found at high $T$ and low $P$

38. A sphere that sits on the corner of a simple cubic unit cell is shared between how many unit cells?
   a. 4  b. 1  c. 8  d. 2

39. As vapor pressure increases, boiling point
   a. increases  b. decreases  c. remains constant

40. As vapor pressure increases, volatility
   a. increases  b. decreases  c. remains constant

41. The resistance of a liquid to flow is called
   a. viscosity  b. surface tension  c. volatility  d. capillary action

42. The curvature of the surface of a liquid in a container is called the
   a. surface tension  b. meniscus  c. capillary action

43. In which of the following states of matter are the particles held the closest together?
   a. gas  b. liquid  c. solid

44. What type of close-packing pattern results in a lattice that has a face-centered cubic unit cell?
   a. AAA  b. BBB  c. ABAB  d. ABCABC

45. Which one of the following properties of a liquid is not affected by an increase in intermolecular forces?
   a. viscosity  b. molecular weight  c. $\Delta H^\circ_{\text{vap}}$  d. boiling point

46. Metals atoms are held together by:
   a. ionic bonds  b. covalent bonds  c. London dispersion forces
d. electrostatic interactions between metal cations and delocalized valence electrons
47. A solution is said to contain 28% phosphoric acid by mass. What does this mean?
   a. 1 mL of this solution contains 28 g of phosphoric acid
   b. 1 L of this solution has a mass of 28 g
   c. 100 g of this solution contains 28 g of phosphoric acid
   d. 1 L of this solution contains 28 mL of phosphoric acid
   e. the density of this solution is 2.8 g/mL

48. The vapor pressure of pure water at 25°C is 23.8 Torr. What is the vapor pressure of a solution prepared by dissolving 18.0 g of glucose (a nonelectrolyte, molar mass = 180 g/mol) in 95.0 g of water?
   a. 26.8 Torr
   b. 0.443 Torr
   c. 23.4 Torr
   d. 2.46 Torr
   e. 0.451 Torr
   f. 161.8 Torr

49. In basic solution:
   a. \([H_3O^+] = [OH^-]\)
   b. \([H_3O^+] < [OH^-]\)
   c. \([H_3O^+] > [OH^-]\)
   d. \([H_3O^+] = 0\)
   e. \([OH^-] = K_w\)
   f. \([H_3O^+] = K_w\)

50. Consider the following reaction at equilibrium: \(2 \text{CO}_2(g) \rightleftharpoons 2 \text{CO}(g) + \text{O}_2(g); \Delta H^o = -514 \text{kJ}\). Increasing the temperature of this reaction at equilibrium will:
   a. increase the concentration of \(\text{O}_2\) (g) at equilibrium
   b. decrease the concentration of \(\text{CO}_2\) (g) at equilibrium
   c. decrease the value of the equilibrium constant
   d. cause the reaction to shift to the right
   e. have no effect

51. What is the pH of a solution that contains \(2.51 \times 10^{-6}\) M \(\text{OH}^-\)?
   a. 8.40
   b. 3.98
   c. 5.60
   d. 7.00
   e. 9.00
   f. 1.00

52. The stronger an acid is, the __________ its \(K_a\) and the __________ its percent dissociation.
   a. larger, greater
   b. smaller, less
   c. larger, less
   d. smaller, greater

53. Consider the equilibrium \(A \rightleftharpoons \text{products}\) with \(k = 0.0448 \text{L} \cdot \text{mol}^{-1} \cdot \text{s}^{-1}\). If a sample initially has a concentration of \(0.140 \text{mol/L}\) of \(A\), what is the concentration in \text{mol/L} of \(A\) after 20.0 s?
   a. 0.896
   b. 0.0646
   c. 0.571
   d. 0.124
   e. –0.756
   f. 0.140

   In a certain first order reaction it takes 240 s for the reactant concentration to decrease to 1/16 of its initial value. The half life of this reaction is
   a. 120 s
   b. 30 s
   c. 60 s
   d. 70 s
   e. 15 s
   f. 480 s

54. Consider a 2nd order reaction \(A \rightleftharpoons \text{products}\) with \(k = 0.0448 \text{L} \cdot \text{mol}^{-1} \cdot \text{s}^{-1}\). If a sample initially has a concentration of 0.140 mol/L of \(A\), what is the concentration in mol/L of \(A\) after 20.0 s?
   a. 0.896
   b. 0.0646
   c. 0.571
   d. 0.124
   e. –0.756
   f. 0.140
56. The pH of a 0.250 M solution of HNO₃ (aq) is
   a. 0.250  
   b. 0.60
   c. 13.40  
   d. 1.78
   e. 13.75  
   f. 14.0

57. At 25°C pKₐ for formic acid = 3.75. For formic acid Kₐ =
   a. 0.57
   b. 5.62 x 10⁻¹¹
   c. 10.25
   d. 1.78
   e. 1.78 x 10⁻⁴
   f. 1.01

58. At some temperature, a mixture of 2.00 mol H₂S, 2.00 mol S₂ and some H₂ are at equilibrium in a 2.00 L vessel. If K = 100 for the reaction 2 H₂ + S₂ ⇌ 2 H₂S, then the [H₂]eq is
   a. 0.0100 M
   b. 0.100 M
   c. 0.0200 M
   d. 0.125 M
   e. 0.0400 M
   f. 0.141 M

59. A reversible reaction A ⇌ B has DH = –40 kJ/mol. If the forward step has an activation energy of 120 kJ/mol, then the reverse step has an activation energy of
   a. –3 kJ/mol
   b. 160 kJ/mol
   c. 3 kJ/mol
   d. 120 kJ/mol
   e. 80 kJ/mol
   f. 120 kJ/mol

60. Which of the following is present in the largest concentration in 1.0 M HClO₄ (aq)?
   a. HClO₄
   b. H₂ClO₄⁺
   c. ClO₄⁻
   d. HClO₃
   e. OH⁻
   f. Cl⁻

61. A catalyst speeds up a reaction principally by
   a. increasing T
   b. decreasing T
   c. increasing K
   d. decreasing Eₐ
   e. increasing A
   f. increasing Eₐ

62. For the reaction 2 H₂ (g) + 2 NO (g) ⇌ N₂ (g) + 2 H₂O (g), a proposed mechanism is:
   step 1: H₂ (g) + 2 NO (g) ⇌ N₂O (g) + H₂O (g); slow
   step 2: N₂O (g) + H₂ (g) ⇌ N₂ (g) + H₂O (g); fast
   The predicted rate law for this mechanism is
   a. Rate = k[N₂O][H₂]
   b. Rate = k[H₂][NO]²
   c. Rate = k[H₂][NO]²
   d. Rate = k[H₂][N₂O]/[N₂]

63. For an acid/base indicator to be useful in a titration, the indicator should have a pKₐ value that is within one unit (± 1) of:
   a. pKₐ of the acid being titrated
   b. pKₐ of the base being titrated
   c. pH at the stoichiometric point
   d. pH of the initial acid solution

64. Which one of the following comparisons of acid strength is incorrect?
   a. pKₐ of HClO₂ < pKₐ of HClO₃
   b. pKₐ of H₂SeO₄ < pKₐ of HSeO₄⁻
   c. pKₐ of H₂SeO₄ < pKₐ of HSeO₄⁻
   d. pKₐ of HCl < pKₐ of HF

65. If each of the following salt solutions has a concentration of 1.0 M, which one has pH = 7.00?
   a. KClO₂ (aq)
   b. NaBr (aq)
   c. NH₄Cl (aq)
   d. Na₃PO₄ (aq)
66. Which one of the following reactions has a negative value of $\Delta S$?
   a. $\text{LiBr (s)} \rightarrow \text{LiBr (aq)}$
   b. $\text{I}_2 (s) \rightarrow \text{I}_2 (g)$
   c. $2 \text{KN}_3 (s) \rightarrow 2 \text{K (s)} + 3 \text{N}_2 (g)$
   d. $\text{Ni (s)} + \text{F}_2 (g) \rightarrow \text{NiF}_2 (s)$

67. When a metal cation reacts with molecules that can donate electron pairs, a ________ forms.
   a. strong acid
   b. complex ion
   c. neutral solution
   d. buffer solution

68. Which one of the following methods could be used to increase the solubility of $\text{Fe(OH)}_2 (s)$?
   a. add $\text{Fe(NO}_3)_2 (aq)$
   b. raise the pH
   c. add $\text{HCl (aq)}$
   d. add $\text{KCl (s)}$

69. A buffer solution is made by dissolving 0.150 mol $\text{HNO}_2 (pK_a = 3.45)$ and 0.350 mol $\text{KNO}_2$ in 500 mL of water. The pH of this solution is:
   a. 3.08
   b. 3.82
   c. 10.10
   d. 10.92

70. A certain reaction has $\Delta H^\circ = +50 \text{kJ/mol}$ and $\Delta S^\circ = +100 \text{J/K\cdot mol}$. This reaction is:
   a. spontaneous at all temperatures
   b. not spontaneous at any temperature
   c. spontaneous only above 500 K
   d. spontaneous only below 200 K

71. 0.300 mol of $\text{NaHC}_2\text{O}_4 (pK_a = 4.19)$ is dissolved in 1.00 L of water. Which one of the following could be added to form a buffer solution with pH = 4.50?
   a. 0.300 mol $\text{NaOH}$
   b. 0.613 mol $\text{Na}_2\text{C}_2\text{O}_4$
   c. 0.147 mol $\text{H}_2\text{C}_2\text{O}_4$
   d. 0.150 mol $\text{HCl}$

72. What is the concentration of $\text{CO}_3^{2-}$ in 0.40 M $\text{H}_2\text{CO}_3 (aq)$? For carbonic acid, $K_{a1} = 4.3 \times 10^{-7}$, and $K_{a2} = 5.6 \times 10^{-11}$.
   a. $4.3 \times 10^{-7} \text{M}$
   b. $0.40 \text{M}$
   c. $5.6 \times 10^{-11} \text{M}$
   d. $2.3 \times 10^{-8} \text{M}$

73. Which of the following aqueous salt solutions (all 0.100 M) has the lowest pH?
   a. $\text{Na}_3\text{PO}_4$
   b. $\text{Na}_2\text{SO}_4$
   c. $\text{NaCl}$
   d. $\text{AlCl}_3$

74. In which of the following molecular orbitals is the probability of finding an electron at the internuclear axis NOT equal to 0?
   a. $\text{S}_2\text{p}$
   b. $\text{P}^*_2\text{p}$
   c. $\text{S}_2\text{p}$
   d. $\text{P}^*_2\text{s}$

75. Consider $\text{P}_2$. Head to head overlap of two 3p orbitals (one on each P atom) leads to the formation of
   a. one S$_{3p}$ and one P$_{3p}$ MO
   b. one P$_{3p}$ and one P$_{3p}$ MO
   c. one S$_{3p}$ and one P$_{3p}$ MO
   d. two S$_{3p}$ and two P$_{3p}$ MO's

76. For which element is the ground state electron configuration [Ar] $4s^2 3d^8$?
   a. Kr
   b. Fe
   c. Cu
   d. Zn
   e. Ni

77. Which of the following elements is the most paramagnetic?
   a. Fe
   b. P
   c. Ar
   d. Sc
   e. Cs

78. What is meant by the term “normal boiling point”?
   a. $T = 25^\circ \text{C}$
   b. $P = 1 \text{ atm}$
   c. bp of pure solvent
   d. bp when there are no intermolecular forces
79. Consider a Galvanic cell represented by the following line notation: \( \text{Zn(s)} \ | \ \text{Zn}^{2+} \ (\text{aq}) \ || \ \text{Cu}^{2+} \ (\text{aq}) \ | \ \text{Cu} \ (\text{s}) \). Which statement about this cell is not true?
   a. The mass of the zinc electrode will increase as the cell discharges.
   b. The copper electrode is the cathode.
   c. Electrons will flow through the external circuit from the zinc electrode to the copper electrode.
   d. The cathode half reaction is \( \text{Cu}^{2+} + 2 \text{e}^{-} \rightarrow \text{Cu} \).
   e. The concentration of \( \text{Cu}^{2+} \ (\text{aq}) \) will decrease as the cell discharges.

80. An electrolytic cell runs with a current of 1.00 A for 30.0 min. What mass (in g) of iron can be plated from FeCl\(_2\) (aq) in this cell?
   a. 0.520 g  
   b. 1.04 g  
   c. 838 g  
   d. 8.71 \times 10^{-3} \text{g}  
   e. 16.6 g
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