Problem Set #3, December 2019

Use the thermodynamic data related to the dissolution of silver chloride to answer questions 41-43. (Assume ΔH and ΔS do not change with temperature)

	$AgCl$	$\rightleftharpoons$	Ag^+	+	Cl^-
ΔH_f^o (kJ/mol)	-127		105		-167
S^o (J/mol)	-109		77		-131

41. We know from experience that dissolution increases with temperature. Explain this observation using the thermodynamic data for silver chloride dissolution.

    a. Both ΔH^o, and ΔS^o are greater than zero
    b. The reaction is exothermic and an increase in temperature pushes the equilibrium towards the products
    c. $\Delta G < 0$ at 25 ^{o}C
    d. The equilibrium of most reactions move towards the products with increasing temperature
    e. Not enough information provided

42. By how much does the solubility of silver chloride increase when you increase the temperature of the solution from 10 ^{o}C to 90 ^{o}C?
    a. 170x
    b. 21x
    c. 76x
    d. 214x
    e. 14x

43. If you have a 1 L container of seawater that has a chloride concentration of 20 mg/L at 25 ^{o}C, how many milliliters (mL) of 1.0 ?M silver nitrate ($AgNO_3$) can you add to the seawater **before** you observe a silver chloride precipitate?
    a. 3.2 mL
    b. 4.5 mL
    c. 17 mL
    d. 5.3 mL
    e. 0.36 mL

44. Which of the following is **not** a redox reaction?

    a. $NO_2(g) + OH(g) \rightarrow HNO_3(g)$
    b. $HOCl(aq) + HCl(aq) \rightarrow Cl_2(g) + H_2O(l)$
    c. $SO_2(g) + OH(g) + O_2(g) \rightarrow SO_3(g) + HO_2(g)$
    d. $2HOCl(aq) \rightarrow Cl_2O(aq) + H_2O(l)$
    e. $SO_2(g) + H_2O_2(aq) \rightarrow SO_3(g) + H_2O(l)$

45. A plume of air near a smoke stack contains a partial pressure of sulfur dioxide gas (SO_2) of 1.0×10^{-7} atm, using the equilibrium reaction shown below calculate the pH of cloud droplets that form in this air plume?

$SO_2(g) + 2H_2O(l) \rightleftharpoons HSO_3^-(aq) + H_3O^+(aq)$ $\quad K = 1.7 \times 10^{-2}$

a. 2.79
b. 5.56
c. 3.26
d. 2.55
e. 4.38

46. You take a bottle of water, toluene and benzyl alcohol out of the freezer. All of the liquids are at 0 °C and all are in the liquid state (water is not frozen). You place 100 g of each of the liquids on a hot plate. Assuming they are all receiving heat energy from the hot plate at the same rate, which liquid will be the **last** to start to boil?

Water: Boiling point 100 °C
Density 1.00 g/mL
Heat Capacity 4.18 J/(g °C)

Toluene: Boiling point 111 °C
Density 0.87 g/mL
Heat Capacity 1.71 J/(g °C)

Benzyl alcohol: Boiling point 205 °C
Density 1.04 g/mL
Heat Capacity 2.03 J/(g °C)

a. Water
b. Toluene
c. Benzyl alcohol
d. Water and toluene
e. Toluene and benzyl alcohol

47. How much energy is evolved when 10.0 moles of carbon disulfide gas (CS_2) react with 15.0 moles of molecular oxygen (O_2) to form carbon dioxide (CO_2) and sulfur dioxide (SO_2)?

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta H = -393.5$ kJ
$S(s) + O_2(g) \rightarrow SO_2(g)$ $\quad \Delta H = -296.8$ kJ
$C(s) + 2S(s) \rightarrow CS_2(g)$ $\quad \Delta H = 117$ kJ

a. 15 400 kJ
b. 22 600 kJ
c. 378 kJ
d. 5520 kJ
e. 11 900 kJ

48. 770.1 kJ of energy is released during a phase change of water between the liquid and gas phases. What was the product, and how much of it was formed?

$H_2O(l) \rightarrow H_2O(g)$ $\Delta H = 44.01$ kJ/mol

a. 44.0 moles of water vapour
b. 44.0 moles of liquid water
c. 17.5 moles of water vapour
d. 17.5 moles of liquid water
e. Not enough information provided

49. With a heat capacity of 1.04 J/(g ^oC), it takes 104 J of heat energy to raise the temperature of 10 g of nitrogen gas (N_2) 10 ^oC. Assuming no change in the heat capacity, is the entropy change that results from this heating equivalent for the following changes in temperature:

ΔT_1: – 100 ^oC to – 90 ^oC
ΔT_2: 200 ^oC to 210 ^oC

a. Yes, ΔS for ΔT_1 and ΔT_2 are equivalent
b. No, ΔS is greater for ΔT_1
c. No, ΔS is greater for ΔT_2
d. Need ΔG
e. Need ΔH

50. As equilibrium is approached the magnitude of ΔG will:

a. Not change
b. Become a larger negative value
c. Become a larger positive value
d. Become a smaller negative value
e. Become a smaller positive value

51. Which of the following statements is true when $E_{cell} = 0$?

a. T = 298 K
b. The reaction is approaching equilibrium
c. The reaction is spontaneous
d. $\Delta G^o = 0$
e. $\Delta G = 0$

52. In the spontaneous reaction between nickel (Ni^{2+}/Ni) and tin ((Sn^{2+}/Sn)) under standard state conditions, which species is the oxidizing agent?

$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$ $E^o = – 0.25$ V $\quad\quad$ $Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$ $E^o = – 0.13$ V

a. $Ni^{2+}(aq)$
b. $Ni^{2+}(s)$
c. $Sn^{2+}(aq)$
d. $Sn(s)$
e. No reaction

53. What is the cell potential (E_{cell}) for the voltaic cell between chromium (0.05 M) and zinc (1.0 M) at the given concentrations at 298 K?

$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$ $\quad E^o = -0.76$ V
$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$ $\quad E^o = -0.74$ V

a. – 0.0056 V
b. 0.0056 V
c. – 0.0026 V
d. 0.0026 V
e. 0.02 V

54. At 25 °C the Ksp of silver phosphate (Ag_3PO_4) is 2.6×10^{-18}. What is the molar solubility of silver phosphate at 25 °C?

a. 1.8×10^{-5} *M*
b. 6.9×10^{-5} *M*
c. 9.6×10^{-15} *M*
d. 8.3×10^{-3} *M*

55. Using the Ksp value provided in question 14, calculate the molar solubility of silver phosphate at 25 °C in the presence of 0.1 *M* potassium phosphate (K_2PO_4).

a. 5.7×10^{-9} *M*
b. 9.9×10^{-7} *M*
c. 6.9×10^{-3} *M*
d. 4.2×10^{-6} *M*

56. For the following systems at equilibrium, choose the system where doubling the volume of the container will cause a shift in the equilibrium towards the products. (Assume constant temperature)

a. $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$
b. $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$
c. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
d. $H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$
e. $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

57. Ammonia (for fertilizer and other uses) is made by causing hydrogen and nitrogen to react at high temperature and pressure. The equation is

$N_2 + H_2 \rightarrow NH_3$ (Not balanced!)

How many grams of ammonia can be made from 70.0 g of hydrogen and 210.1 g of nitrogen?

a. 238
b. 255
c. 267
d. 275
e. 280

58. The pH at the equivalence point of a titration of 100 mL of 0.50 M benzoic acid (C_6H_5COOH) is 8.95. What is the K_a of benzoic acid?

a. 6.3×10^{-5}
b. 1.8×10^{-4}
c. 3.2×10^{-6}
d. 8.9×10^{-6}
e. 8.9×10^{-4}

59. The pKa of the anilinium ion ($C_6H_5NH_3^+$) is 4.87. Your blood is buffered to pH 7.4, if you ingest aniline ($C_6H_5NH_2$), which of the following statements is **true**?

a. The anilinium ion ($C_6H_5NH_3^+$) is the dominant species present
b. Aniline ($C_6H_5NH_2$) is the dominant species present
c. The anilinium ion ($C_6H_5NH_3^+$) and aniline ($C_6H_5NH_2$) are present at similar concentrations
d. You would need to perform a titration to determine the speciation of aniline
e. Not enough information given

60. How many grams of gold could be plated out on the cathode of an electrolytic cell by the passage of 0.50 Amps of current through a solution of gold nitrate ($AuNO_3$) for 30 minutes?

a. 3.07×10^{-2} g
b. 2.41 g
c. 3.68 g
d. 1.84 g
e. 17.9 g