NAME_____

Su2014/CHEM1451/Exam 4/Dooley

August 1, 2014

125 Points Total

Multiple Choice: (4 Points Each) Place the letter corresponding to the correct answer to the left of each problem number.

_____1. When titrating a weak acid with NaOH, the
- a. pH will be less than 7 at the equivalence point.
- b. pH will be equal to 7 at the equivalence point.
- c. pH will be greater than 7 at the equivalence point.
- d. titration will require more moles of base than acid to reach the equivalence point.
- e. titration will require more moles of acid than base to reach the equivalence point.

_____2. In a weak acid titration with a strong base, the equivalence point is found to occur at 60 mL of added base. What did the pH equal after only adding 30 mL of base?
- a. The pK_a of the weak acid
- b. The pK_b of the weak acid
- c. The pH varies depending on the base you are using
- d. pH = 7
- e. pH = 3.5

_____3. A 60 mL sample of 0.400M hypochlorous acid ($K_a = 2.9 \times 10^{-8}$) is titrated with 0.100M NaOH. What is the pH of the sample before any base is added?
- a. 1.95
- b. 3.97
- c. 10.03
- d. 7.00
- e. None of the above

_____4. When you compare the titration curves of several weak acids of the same molarity with a strong base, which of the following indicates that you are looking at the curve for the weakest of the acids?
- a. The pH jump at the equivalence point is the largest
- b. The initial pH is the lowest, and it takes more base to neutralize.
- c. The pH in the buffer region is the highest and the pH at the equivalence point is the highest.
- d. The equivalence point occurs with less base added.
- e. You can't tell the strength of the acid from its titration curve.

_____5. Which of the following compounds will be more soluble in acidic solution than in pure water?

a. $PbCl_2$
b. $FeCO_3$
c. $Ca(NO_3)_2$
d. CuI
e. None of the above will be more soluble in acidic solution.

_____6. Determine the molar solubility of $PbSO_4$ in pure water. K_{sp} ($PbSO_4$) = 1.82×10^{-8}.

a. 1.82×10^{-8} M
b. 1.35×10^{-4} M
c. 9.1×10^{-9} M
d. 3.31×10^{-16} M
e. 4.48×10^{-4} M

_____7. Write the reaction associated with the solubility product of $Pb(CO_3)_2$.

a. $Pb^{4+}(aq) + 2CO_3^{2-}(aq) \rightleftharpoons Pb(CO_3)_2(s)$
b. $Pb(CO_3)_2(s) \rightleftharpoons Pb^{4+}(aq) + 2CO_3^{2-}(aq)$
c. $Pb^{4+}(aq) + 2CO_3^{2-}(aq) \rightleftharpoons Pb(CO_3)_2(aq)$
d. $Pb(s) + C(s) + O_2(g) \rightleftharpoons Pb(CO_3)_2(s)$
e. None of the above

_____8. Write the expression for the solubility product for $Pb(CO_3)_2$.

a. $K_{sp}=[Pb(CO_3)_2]$
b. $K_{sp}=[Pb^{4+}][CO_3^{2-}]^2$
c. $K_{sp} = \frac{[Pb^{4+}][CO_3^{2-}]^2}{[Pb(CO_3)_2]}$
d. $K_{sp} = \frac{[Pb(CO_3)_2]}{[Pb^{4+}][CO_3^{2-}]^2}$
e. None of the above

_____9. If an ionic compound is dissolved in an unsaturated solution, how does Q compare with Ksp.

a. Q < Ksp
b. Q > Ksp
c. Q = Ksp
d. Q is totally unrelated to Ksp, so there is no way to tell
e. Q is related to K, but doesn't tell you if a solution is saturated

_____10. Which of the following processes have a $\Delta S > 0$?

a. $CH_3OH(l) \rightarrow CH_3OH(s)$
b. $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$
c. $CH_4(g) + H_2O(g) \rightarrow CO(g) + 3\ H_2(g)$
d. $Na_2CO_3(s) + H_2O(g) + CO_2(g) \rightarrow 2\ NaHCO_3(s)$
e. All of the above processes have a $\Delta S > 0$.

_____11. Which of the following statements is TRUE?

a. Entropy is not a state function.
b. Endothermic processes decrease the entropy of the surroundings, at constant T and P.
c. Endothermic processes are never spontaneous.
d. Exothermic processes are always spontaneous.
e. None of the above are true.

_____12. Consider a reaction that has a negative ΔH and a positive ΔS. Which of the following statements is TRUE?

a. This reaction will be spontaneous only at high temperatures.
b. This reaction will be spontaneous at all temperatures.
c. This reaction will be nonspontaneous at all temperatures.
d. This reaction will be nonspontaneous only at high temperatures.
e. It is not possible to determine without more information.

_____13. Consider a reaction that has a positive ΔH and a positive ΔS. Which of the following statements is TRUE?

a. This reaction will be spontaneous only at high temperatures.
b. This reaction will be spontaneous at all temperatures.
c. This reaction will be nonspontaneous at all temperatures.
d. This reaction will be nonspontaneous only at high temperatures.
e. It is not possible to determine without more information.

_____14. Consider the following reaction at constant P. Use the information here to determine the value of ΔS_{surr} at 298 K. Predict whether or not this reaction will be spontaneous at this temperature based on what you know about the ΔS_{sys}.

$N_2(g) + 2\ O_2(g) \rightarrow 2\ NO_2(g)$ $\Delta H = +66.4$ kJ

a. ΔSsurr = +223 J/K, reaction is spontaneous
b. ΔSsurr = -223 J/K, reaction is not spontaneous
c. ΔSsurr = -66.4 J/K, reaction is spontaneous
d. ΔSsurr = +66.4 kJ/K, reaction is not spontaneous
e. ΔSsurr = -66.4 J/K, it is not possible to predict the spontaneity of this reaction without more information

_____15. What is the sign for ΔG and ΔS_{univ} for a spontaneous process?

a. Both are positive
b. Both are negative
c. ΔG is positive, and you must calculate ΔS_{univ} to determine its sign
d. ΔG is positive and ΔS_{univ} is negative
e. ΔG is negative and ΔS_{univ} is positive

_____16. For the following example, identify the following.

$H_2O\ (l) \rightarrow H_2O(s)$

a. a negative ΔH and a negative ΔS
b. a positive ΔH and a negative ΔS
c. a negative ΔH and a positive ΔS
d. a positive ΔH and a positive ΔS
e. It is not possible to determine without more information.

_____17. Choose the reaction that illustrates $\Delta H°_f$ for $Ca(NO_3)_2$ which is a solid in its standard state.

a. $Ca(s) + N_2(g) + 3O_2(g) \rightarrow Ca(NO_3)_2(s)$
b. $Ca^{2+}(aq) + 2\ NO^{3-}(aq) \rightarrow Ca(NO_3)_2(aq)$
c. $Ca(s) + 2\ N(g) + 6\ O(g) \rightarrow Ca(NO_3)_2(s)$
d. $Ca(NO_3)_2(aq) \rightarrow Ca^{2+}(aq) + 2\ NO^{3-}(aq)$
e. $Ca(NO_3)_2(s) \rightarrow Ca(s) + N_2(g) + 3O_2(g)$

_____18. Calculate $\Delta S°_{rxn}$ for the following reaction. The S° for each species is shown below the reaction.

$C_2H_2(g) + 2\ H_2(g) \rightarrow C_2H_6(g)$

S°(J/mol·K) 200.9 130.7 229.2

a. +303.3 J/K
b. +560.8 J/K
c. -102.4 J/K
d. -233.1 J/K
e. 229.2 J/K

_____19. Calculate $\Delta G°_{rxn}$ for the following reaction at 449.0 K.

$CH_2O(g) + 2\ H_2(g) \rightarrow CH_4(g) + H_2O(g)$
ΔH°= -94.9 kJ; ΔS°= -224.2 J/K

a. +5.8 kJ
b. +12.9 kJ
c. -101 kJ
d. +2.4 kJ
e. -4.2 kJ

_____20. Calculate ΔG_{rxn} at 298 K under the conditions shown below for the following reaction.

$2\ Hg(g) + O_2(g) \rightarrow 2\ HgO(s)$ $\Delta G° = -180.8$ kJ

P(Hg) = 0.025 atm, $P(O_2)$ = 0.037 atm

a. +207 kJ
b. -154.4 kJ
c. -26.5 kJ
d. -164 kJ
e. +60.7 kJ

Problems: To receive credit on the following problems, be sure to Show all necessary calculations as well as written reactions.

1. (15 Pts) A 100.0 mL sample of 0.10 M NH_3 is titrated with 0.15 M HNO_3. Determine the pH of the solution after the addition of 80.0 mL of HNO_3.
   (The K_b of NH_3 is 1.8×10^{-5}.)

2. (15 Points) A 50.0 mL sample of 0.200 M HCN is titrated with 0.10M NaOH. Determine the pH of the solution after the addition of 30.0 mL of NaOH.
(The K_a of HCN is 4.9×10^{-10})

3. (10 Points) Above what temperature does the following reaction become nonspontaneous?

$$2\ H_2S(g) + 3\ O_2(g) \rightarrow 2\ SO_2(g) + 2\ H_2O(g)$$

$\Delta H = -1036$ kJ; $\Delta S = -153.2$ J/K

4. (12 Points) Use Hess's law to calculate ΔG°_{rxn} using the following information.

   $CO(g) \rightarrow C(s) + 1/2\ O_2(g)$ $\quad \Delta G^\circ_{rxn} = ?$

   $CO_2(g) \rightarrow C(s) + O_2(g)$ $\quad \Delta G^\circ_{rxn} = +394.4$ kJ

   $CO(g) + 1/2\ O_2(g) \rightarrow CO_2(g)$ $\quad \Delta G^\circ_{rxn} = -257.2$ kJ

5. (8 Points) Use the free energies of formation given below to calculate the equilibrium constant (K) for the following reaction at 298 K.

$$2\ HNO_3(aq) + NO(g) \rightarrow 3\ NO_2(g) + H_2O(l) \quad K = ?$$

ΔG°_f (kJ/mol)	-110.9	87.6	51.3	-237.1