

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
- pH will be less than 7 at the equivalence point.
 - pH will be equal to 7 at the equivalence point.
 - pH will be greater than 7 at the equivalence point.
 - titration will require more moles of base than acid to reach the equivalence point.
 - 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?
- The pK_a of the weak acid
 - The pK_b of the weak acid
 - The pH varies depending on the base you are using
 - pH = 7
 - 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?
- 1.95
 - 3.97
 - 10.03
 - 7.00
 - 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?
- The pH jump at the equivalence point is the largest
 - The initial pH is the lowest, and it takes more base to neutralize.
 - The pH in the buffer region is the highest and the pH at the equivalence point is the highest.
 - The equivalence point occurs with less base added.
 - 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?
- PbCl_2
 - FeCO_3
 - $\text{Ca}(\text{NO}_3)_2$
 - CuI
 - None of the above will be more soluble in acidic solution.

- _____ 6. Determine the molar solubility of PbSO_4 in pure water. $K_{\text{sp}}(\text{PbSO}_4) = 1.82 \times 10^{-8}$.
- $1.82 \times 10^{-8} \text{ M}$
 - $1.35 \times 10^{-4} \text{ M}$
 - $9.1 \times 10^{-9} \text{ M}$
 - $3.31 \times 10^{-16} \text{ M}$
 - $4.48 \times 10^{-4} \text{ M}$

- _____ 7. Write the reaction associated with the solubility product of $\text{Pb}(\text{CO}_3)_2$.
- $\text{Pb}^{4+}(\text{aq}) + 2\text{CO}_3^{2-}(\text{aq}) \rightleftharpoons \text{Pb}(\text{CO}_3)_2(\text{s})$
 - $\text{Pb}(\text{CO}_3)_2(\text{s}) \rightleftharpoons \text{Pb}^{4+}(\text{aq}) + 2\text{CO}_3^{2-}(\text{aq})$
 - $\text{Pb}^{4+}(\text{aq}) + 2\text{CO}_3^{2-}(\text{aq}) \rightleftharpoons \text{Pb}(\text{CO}_3)_2(\text{aq})$
 - $\text{Pb}(\text{s}) + \text{C}(\text{s}) + \text{O}_2(\text{g}) \rightleftharpoons \text{Pb}(\text{CO}_3)_2(\text{s})$
 - None of the above

- _____ 8. Write the expression for the solubility product for $\text{Pb}(\text{CO}_3)_2$.
- $K_{\text{sp}} = [\text{Pb}(\text{CO}_3)_2]$
 - $K_{\text{sp}} = [\text{Pb}^{4+}][\text{CO}_3^{2-}]^2$
 - $K_{\text{sp}} = \frac{[\text{Pb}^{4+}][\text{CO}_3^{2-}]^2}{[\text{Pb}(\text{CO}_3)_2]}$
 - $K_{\text{sp}} = \frac{[\text{Pb}(\text{CO}_3)_2]}{[\text{Pb}^{4+}][\text{CO}_3^{2-}]^2}$
 - None of the above

- _____ 9. If an ionic compound is dissolved in an unsaturated solution, how does Q compare with K_{sp} .
- $Q < K_{\text{sp}}$
 - $Q > K_{\text{sp}}$
 - $Q = K_{\text{sp}}$
 - Q is totally unrelated to K_{sp} , so there is no way to tell
 - Q is related to K, but doesn't tell you if a solution is saturated

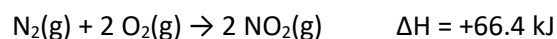
- _____ 10. Which of the following processes have a $\Delta S > 0$?
- $\text{CH}_3\text{OH}(\text{l}) \rightarrow \text{CH}_3\text{OH}(\text{s})$
 - $\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightarrow 2 \text{NH}_3(\text{g})$
 - $\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{CO}(\text{g}) + 3 \text{H}_2(\text{g})$
 - $\text{Na}_2\text{CO}_3(\text{s}) + \text{H}_2\text{O}(\text{g}) + \text{CO}_2(\text{g}) \rightarrow 2 \text{NaHCO}_3(\text{s})$
 - All of the above processes have a $\Delta S > 0$.

- _____11. Which of the following statements is TRUE?
- Entropy is not a state function.
 - Endothermic processes decrease the entropy of the surroundings, at constant T and P.
 - Endothermic processes are never spontaneous.
 - Exothermic processes are always spontaneous.
 - 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?
- This reaction will be spontaneous only at high temperatures.
 - This reaction will be spontaneous at all temperatures.
 - This reaction will be nonspontaneous at all temperatures.
 - This reaction will be nonspontaneous only at high temperatures.
 - It is not possible to determine without more information.

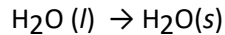
- _____13. Consider a reaction that has a positive ΔH and a positive ΔS . Which of the following statements is TRUE?
- This reaction will be spontaneous only at high temperatures.
 - This reaction will be spontaneous at all temperatures.
 - This reaction will be nonspontaneous at all temperatures.
 - This reaction will be nonspontaneous only at high temperatures.
 - 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} .



- $\Delta S_{\text{surr}} = +223 \text{ J/K}$, reaction is spontaneous
 - $\Delta S_{\text{surr}} = -223 \text{ J/K}$, reaction is not spontaneous
 - $\Delta S_{\text{surr}} = -66.4 \text{ J/K}$, reaction is spontaneous
 - $\Delta S_{\text{surr}} = +66.4 \text{ kJ/K}$, reaction is not spontaneous
 - $\Delta S_{\text{surr}} = -66.4 \text{ J/K}$, 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?
- Both are positive
 - Both are negative
 - ΔG is positive, and you must calculate ΔS_{univ} to determine its sign
 - ΔG is positive and ΔS_{univ} is negative
 - ΔG is negative and ΔS_{univ} is positive

_____16. For the following example, identify the following.

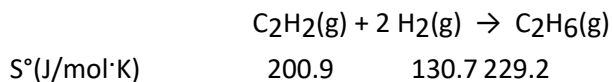


- a. a negative ΔH and a negative ΔS
- b. a positive ΔH and a negative ΔS
- c. a negative ΔH and a positive ΔS
- d. a positive ΔH and a positive ΔS
- e. It is not possible to determine without more information.

_____17. Choose the reaction that illustrates ΔH°_f for $\text{Ca}(\text{NO}_3)_2$ which is a solid in its standard state.

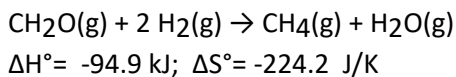
- a. $\text{Ca}(s) + \text{N}_2(g) + 3\text{O}_2(g) \rightarrow \text{Ca}(\text{NO}_3)_2(s)$
- b. $\text{Ca}^{2+}(\text{aq}) + 2 \text{NO}_3^-(\text{aq}) \rightarrow \text{Ca}(\text{NO}_3)_2(\text{aq})$
- c. $\text{Ca}(s) + 2 \text{N}(g) + 6 \text{O}(g) \rightarrow \text{Ca}(\text{NO}_3)_2(s)$
- d. $\text{Ca}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + 2 \text{NO}_3^-(\text{aq})$
- e. $\text{Ca}(\text{NO}_3)_2(s) \rightarrow \text{Ca}(s) + \text{N}_2(g) + 3\text{O}_2(g)$

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



- 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 $\Delta G^\circ_{\text{rxn}}$ for the following reaction at 449.0 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.



$P(\text{Hg}) = 0.025 \text{ atm}$, $P(\text{O}_2) = 0.037 \text{ atm}$

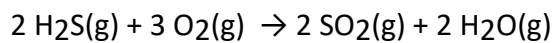
- a. +207 kJ
- b. -154.4 kJ
- c. -26.5 kJ
- d. -164 kJ
- e. +60.7 kJ

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} .)

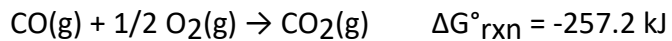
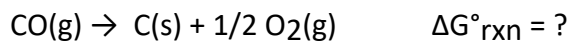
2. (15 Points) A 50.0 mL sample of 0.200 M HCN is titrated with 0.10M NaOH. Determine the pH of the solution after the addition of 30.0 mL of NaOH.
(The K_a of HCN is 4.9×10^{-10})

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



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

4. (12 Points) Use Hess's law to calculate $\Delta G^\circ_{\text{rxn}}$ using the following information.



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

