SF

CHM 2046
HOMEWORK SET 2

SANTA FE COLLEGE Chemistry

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OFFICE HOURS: ANNOUNCED IN CLASS AND POSTED ON OFFICE DOOR

REVIEW QUESTIONS ABOUT ACIDS AND BASES

1. What is the definition of a Brønsted-Lowry acid? What is the definition of a Brønsted-Lowry base?

2. What chemical feature MUST be present IF a species is to function as a Brønsted-Lowry acid? This is not to say that any chemical that possesses this feature WILL function as a Brønsted-Lowry acid.

3. What chemical feature MUST be present IF a species is to function as a Brønsted-Lowry base? This is not to say that any chemical that possesses this feature WILL function as a Brønsted-Lowry base.

4. What are the products of any acid/base reaction?

5. What are the conjugate acids of the following species?

   a) H_2O b) OH^- c) NH_3 d) X^- e) HX

6. What are the conjugate bases of the following species?
   a) H_2O b) OH^- c) NH_3 d) HX e) H_3O^+

7. In terms of their reaction with water, how are strong acids defined? How are weak acids defined?

8. Write the equation for the reaction of a strong acid, HX, with water. Write the equation for the reaction of a weak acid, HX, with water. What is the difference between the two equations? Explain.

9. What are the six common strong acids? Memorize them! How then, are all other acids classified?

10. Remember: An inventory is a list of the formulas and concentrations of the solute ions and molecules present in appreciable amounts in a solution. What is the inventory of 1M HCl? What is the inventory of a 1 M solution of any strong acid, HX? A 1 M solution of any weak acid, HY?

11. Explain why liquid HCl does not conduct electricity but a 1M HCl solution does conduct.

12. How would the conductivity of a 1M HCl solution differ from the conductivity of a 1M $HC_2H_3O_2$ solution? Explain.

13. If the conductivity of an aqueous solution of acid HZ were such that the 150 watt bulb lit brightly while the aqueous solution of acid HY lit only the 7.5 watt bulb dimly, what conclusion can one safely draw from these observations about the relative acid strengths of HZ and HY? Explain.

14. In terms of their reaction with water, how are strong bases defined? How are weak bases defined?

15. Write the equation for the reaction of a strong base, B, with water. Write the equation for the reaction of a weak base, B, with water. What is the difference between the two equations? Explain.

16. What are the nine common strong bases? Memorize them! How then, are all other bases classified?

17. What is the inventory of a 1M Na_2O solution? What is the inventory of a 1 M solution of any strong base? A 1 M solution of any weak base?

18. Explain why liquid NH_3 does not conduct electricity but a 1M NH_3 solution does conduct (slightly).

19. Explain why conductivity can be used to determine the relative strengths amongst a group of molecular acids or amongst a group of molecular bases but cannot be used to determine the relative strengths amongst a group of ionic acids or amongst a group of ionic bases.

20. If the conductivity of an aqueous solution of base Z was such that the 7.5 watt bulb lit brightly while the aqueous solution of base Y lit only the 7.5 watt bulb dimly, what conclusion can one safely draw from these observations about the relative base strengths of Z and Y? Explain.

21. You are given the hypothetical acids HR, HG, and HY which are colorless, in the pure form. Their respective bases however, are highly colored; R^- being red, G^- being green, and Y^- being yellow in solution. Consider the following experiments.

    i. When HR is mixed with water, the resulting solution is only a faint pink.

    ii. When a solution of HR (eg. 1M HR) is mixed with a solution containing G^- (eg. 1M NaG) the resulting solution is a deep red color.

    iii. When HY is mixed with water, the resulting solution is a deep yellow.

    A) Write the equations which correspond to the changes in each of the above reactions and indicate the relative extent to which each occurred.

    B) For each of the equations in A, decide which acid is the stronger, the acid on the left side or the acid on the right side.

    C) For each of the equations in A, decide which base is the stronger, the base on the left side or the base on the right side.

    D) Now prepare an acid/base table similar to the one presented in class which lists your FOUR acids and their FOUR conjugate bases. Consult your notes to see how to properly list them!

    E) If a solution of a fourth acid, HB (eg. 1M HB) (which is colorless), is mixed with a solution of R^- (eg. 1M NaR) and the resulting solution is a deep red, where does the acid HB belong in your table? Can it be placed unambiguously? If not what reaction or reactions would you perform in order to correctly place acid HB in your chart?

QUESTIONS ON EQUATION WRITING

22. Write the equation for the principal acid/base reaction which occurs when **equal volumes** of the following solutions are mixed. Also, comment on the extent of the reaction as written.

a. 0.1 M HCl with 0.1 M KOH

b. 0.1 M HNO_3 with 0.1 M NH_3

c. 0.1 M H_2SO_4 with 0.1 M $NaC_2H_3O_2$

d. 0.1 $NaHSO_4$ with 0.1 M $NaC_2H_3O_2$

e. 0.1 M NH_4Cl with 0.1 M NaOH

f. 0.1 M $NaHCO_3$ with 0.1 M LiOH

g. 0.1 M $HC_2H_3O_2$ with 0.1 M $NaC_2H_3O_2$

h. 0.1 M $HC_2H_3O_2$ with 0.1 M $MgSO_4$ (NOTE: $Mg(H_2O)_6^{+2}$ is a weaker acid than $HC_2H_3O_2$)

i. 0.1 M $HC_2H_3O_2$ with H_2O (i.e., vinegar is diluted)

QUESTIONS ABOUT THE AUTO-IONIZATION OF WATER

23. What equilibrium is present in pure water? Is this equilibrium present in any water sample including aqueous solutions?

24. Write the equilibrium constant expression for the equilibrium present in problem 23. What is the value of this constant?

25. Solve the equilibrium in problem 24 and determine the $[H_3O^+]$ and $[OH^-]$ in pure water.

26. Use Le Châtelier's principle to determine which way the above equilibrium will shift if an acid is added to pure water. What happens to the $[H_3O^+]$ and $[OH^-]$ when the acid is added to pure water?

27. Use Le Châtelier's principle to determine which way the above equilibrium will shift if a base is added to pure water. What happens to the $[H_3O^+]$ and $[OH^-]$ when the base is added to pure water?

QUESTIONS ABOUT SOLUTIONS OF STRONG ACIDS AND BASES

28. Consider a 0.10 M HCl solution.

a) What reaction took place when the solution was prepared?

b) Is there an equilibrium present in the solution?

c) What is that equilibrium? (See problem 23!).

d) Does this equilibrium contribute any significant amount to the total $[H_3O^+]$? Explain.

e) Calculate the $[H_3O^+]$ in the solution. What is the $[OH^-]$ in the solution? What is the pH?

29. Consider a 0.10 M NaOH solution.

a) What reaction took place when the solution was prepared?

b) Is there an equilibrium present in the solution?

c) What is that equilibrium? (See problem 23!).

d) Does this equilibrium contribute any significant amount to the total [OH^-]? Explain.

e) Calculate the [OH^-] in the solution. What is the pH of the solution?

30. Consider a 5.0×10^{-8} M HBr solution.

a) What reaction took place when the solution was prepared?

b) Is there an equilibrium present in the solution?

c) What is that equilibrium? (See problem 23!).

d) Does this equilibrium contribute any significant amount to the total [H_3O^+]? Explain.

e) Solve the equilibrium to determine the total [H_3O^+] in the solution. What is the [OH^-] in the solution?

31. Use the procedure (a-e) used in problems 28 thru 30 to determine the [H_3O^+] in the following solutions.

a) 1.0 M HNO_3 b) 2.0×10^{-4} M HCl

c) 3.0×10^{-8} M $HClO_4$ d) 1.0 M NaOH

e) 1.0×10^{-4} M $Ba(OH)_2$ f) 3.0×10^{-8} M RbOH

32. Calculate the pH of the solutions listed in problem 31.

33. Calculate the [H_3O^+] and [OH^-] in the following solutions.

a) pH = -0.50 b) pH = 1.0

c) pH = 4.30 d) pH = 9.7

e) pH = 14.60

QUESTIONS ON WEAK ACIDS AND BASES

34. Consider a 1.0 M $HC_8H_7O_2$ (phenylacetic acid) solution.

    a) What is the principal equilibrium in this solution?

    b) Write the equilibrium constant expression for this equilibrium. The value for this constant is 4.9×10^{-5}.

    c) Is there any other equilibrium present in this solution? If so, what is it?

    d) What simplifying assumptions can be made?

    e) Calculate the $[H_3O^+]$ in the solution. What is the $[OH^-]$ in the solution? Are the assumptions that you made in part d valid? If not then you must "solve the quadratic" in part b to get the correct $[H_3O^+]$.

35. Consider a 0.00010 M $HC_8H_7O_2$ (phenylacetic acid) solution.

    a) What is the principal equilibrium in this solution?

    b) Write the equilibrium constant expression for this equilibrium. Look up the value for this constant.

    c) Is there any other equilibrium present in this solution? If so, what is it?

    d) What simplifying assumptions can be made?

    e) Calculate the $[H_3O^+]$ in the solution. What is the $[OH^-]$ in the solution? Are the assumptions that you made in part d valid? If not then you must "solve the quadratic" in part b to get the correct $[H_3O^+]$.

36. Calculate the $[H_3O^+]$, the $[OH^-]$, and the pH for the following solutions.
    Don't forget to check any assumptions that you make.

    a) 0.50 M $HC_2H_3O_2$ $K_a = 1.8 \times 10^{-5}$

    b) 0.0035 M HOCl $K_a = 2.9 \times 10^{-8}$

    c) 0.30 M $NaHSO_4$ $K_a = 1.2 \times 10^{-2}$

    d) 0.010 M HIO_3 $K_a = 1.6 \times 10^{-1}$

37. Calculate the value of K_b for the following bases (look up any constants needed).

a) $C_2H_3O_2^-$ b) SO_4^{-2} c) CO_3^{-2-}

38. Consider a 1.0 M $NaC_2H_3O_2$ solution.

a) What is the principal equilibrium in this solution?

b) Write the equilibrium constant expression for this equilibrium. Calculate the value for this constant.

c) Is there any other equilibrium present in this solution? If so, what is it?

d) What simplifying assumptions can be made?

e) Calculate the $[OH^-]$ in the solution. What is the $[H_3O^+]$ in the solution? Are the assumptions that you made in part d valid? If not then you must "solve the quadratic" in part b to get the correct $[OH^-]$.

39. Consider a 0.75 M NaOCl (about the same concentration as in bleach) solution .

a) What is the principal equilibrium in this solution?

b) Write the equilibrium constant expression for this equilibrium. Calculate the value for this constant.

c) Is there any other equilibrium present in this solution? If so, what is it?

d) What simplifying assumptions can be made?

e) Calculate the $[OH^-]$ in the solution. What is the $[H_3O^+]$ in the solution? Are the assumptions that you made in part d valid? If not then you must "solve the quadratic" in part b to get the correct $[OH^-]$. Calculate the pH.

40. What species does the principal acid/base equilibrium in any system involve?
What species does the principal pH determining equilibrium in any system involve?

41. Write the principal acid/base equilibrium and the principal pH determining equilibrium for each of the following systems.

a) 1 M $HC_2H_3O_2$.

b) A mixture of 1 M $HC_2H_3O_2$ and 1 M $NaC_2H_3O_2$.

c) 1 M $(NH_4)_2SO_4$ d) 1 M $NaHCO_3$

42. Which of the solutions in problem 41 can be used a buffers? Explain.

43. Calculate the pH of each solution in problem 41.

44. Calculate the final pH if 0.10 moles of HCl are added to 1.0 L of each solution in problem 41 (assume that no change in volume occurs when the HCl is added). Did the pH change significantly? How "good" of a buffer is each solution?

45. Calculate the final pH if 0.10 moles of NaOH are added to 1.0 L of each solution in problem 41 (assume that no change in volume occurs when the NaOH is added). Did the pH change significantly? How "good" of a buffer is each solution?