WORKSHEET: SOLUTION EQUILIBRIUM (Weak acids and bases, buffers, Polyprotic acids, and Hydrolysis.)

SET A:

1. 40.00 ml of 0.350 M CH_3NH_2 is titrated with 0.280 M HCl until the end point is reached . Calculate the pH of the solution at the end point.(K_b for CH_3NH_2= 5.0 x 10^{-4})

Setup:

Answer: 5.74

2. How many moles of HNO_2 must be added to a 1.00 liter of 0.370 M $NaNO_2$ to give a buffer of pH= 4.20? (Ignore any volume change due to the addition of HNO_2) (K_a for HNO_2 is 4.5×10^{-4}).
Setup:

Answer: 0.052 moles

3. a. Is $NaHCO_3$ (aq) acidic, basic, or neutral ?You must show your work to justify your answer. (K_{a1} for H_2CO_3 = 4.3 x 10-7, Ka_2 for HCO_3^- = 4.8×10^{-11})
Setup:

Answer: K_b for HCO_3^- is larger than Ka_2 for HCO_3^-, $NaHCO_3$ (aq) is basic.

b. Is $NaHCO_3$ (aq) a buffer? (You must show your work to prove that your answer is not a guess.)
Setup:

Answer: Yes

4. How many moles of NaOH must be added to a 1.00 liter of 0.230 M benzoic acid, $HC_7H_5O_2$, to produce a solution of pH= 4.50? (Ka for $HC_7H_5O_2 = 6.3 \times 10^{-5}$)
Setup:

Answer: 0.15 mole

5. The $[S^{2-}]$ concentration of a 0.150 M H_2S is adjusted to a value of 4.18×10^{-8} moles/liter. What is the $[H^+]$ concentration?
(K_{a1} for $H_2S = 8.9 \times 10^{-8}$, K_{a2} for HS^- is 1.2×10^{-13})
Setup:

Answer: 1.9×10^{-7} M

6. What is the $[H^+]$ concentration of a solution made by adding 35.00 ml of 0.660 M $C_6H_5NH_2$ to 40.00 ml of 0.420 M HCl? (K_b for $C_6H_5NH_2$ is 4.6×10^{-7})

Setup:

Answer: 5.9×10^{-8} M

7. Predict whether the following solutions are acidic, basic, or neutral. Write the equilibrium equations, and all calculations if needed, to justify your answer. (K_b for NH_3 is 1.8×10^{-5} , K_a for HClO is 3.5×10^{-8})

a. NH_4ClO

Setup:

Answer: K_b for ClO^- > Ka for NH_4^+ , Basic

b. $NaNO_2$

Setup:

Answer: Basic

c. $Ni(NO_3)_3$

Setup:

Answer: Acidic

SET B:

1. How many moles of $HCHO_2$ must be added to a 1.00 liter of 0.400 M $NaCHO_2$ to give a buffer of pH= 3.60? Ignore any volume change due to the addition of $HCHO_2$. (Ka for $HCHO_2$=1.8×10^{-4})

Setup:

Answer: 0.55 mole

2. a. Is Na_2HPO_4 (aq) a buffer? You must show your work to prove that your answer is not a guess.
Setup:

Answer: Yes

b. Is Na_2HPO_4 acidic, basic, or neutral? You must show your work to justify your answer.
Ka_3 for HPO_4^{2-} is 1.00×10^{-12} , K_{a2} for $H_2PO_4^-$ is 6.2×10^{-8}
Setup:

Answer: K_b (for HPO_4^{2-}) > K_{a3} (for HPO_4^{2-}), Basic

3. What is the $[H^+]$ concentration of a solution made by titrating 30.00 ml of 0.7200 M $C_6H_5NH_2$ with 0.2500 M HCl until the equivalence point is reached? K_b for $C_6H_5NH_2$ is 4.6×10^{-7} .
Setup:

Answer: 6.4×10^{-5}

4. Predict whether each of the following solutions is acidic, basic, or neutral. Write the equilibrium equations, and all calculations if needed, to justify your answer. K_b for NH_3= 1.8 x 10^{-5}, K_a for $HCHO_2$ is 1.8 x 10^{-4}.

a. NH_4CHO_2
Setup:

Answer: K_a (for NH_4^+) > Kb (for CHO_2^-) , Acidic

b. $N_{a2}S$
Setup:

Answer: Basic

c. Cr $(NO_3)_3$
Setup:

Answer: Acidic

5. The $C_6H_6O_6^{2-}$, ascorbate ion, concentration of a 0.270 M ascorbic acid, is adjusted to a value of 8.5 x 10^{-8} mole/liter. What is the $[H^+]$ concentration? K_{a1} for $H_2C_6H_6O_6$ is 7.9 x 10^{-5} and K_{a2} for $HC_6H_6O_6^-$ is 1.6 x 10^{-12}.
Setup:

Answer: 2.0 x 10^{-5} M

6. How many moles of NaOH should be added to a 1.00 liter of 0.190 M HNO_2 to produce a solution of pH= 4.80? Assume there is no change in volume upon the addition of NaOH. K_a for HNO_2 is 4.5×10^{-4} .
Setup:

Answer: 0.18 mole

7) What is the pH of a solution made by mixing 25.00 ml of 0.440 M CH_3NH_3Cl and 37.00 ml of 0.200 M NaOH? K_b for CH_3NH_2 is 5.0×10^{-4}.

Setup:

Answer: pH= 11.00

SET C:

1. The oxalate ion concentration, $C_2O_4^{2-}$, of 0.20 M $H_2C_2O_4$ is adjusted to a value of 3.00×10^{-3} M. What is the $[H^+]$ ion concentration in the solution? K_{a1} for $H_2C_2O_4$ is 5.6×10^{-2} and K_{a2} for $HC_2O_4^-$ is 5.1×10^{-5}.

Setup:

Answer: 1.4×10^{-2} M

2. Predict whether each of the following solutions is acidic, basic, or neutral. Write the equilibrium equations , and all calculations if needed, to justify your answer. Kb for NH_3 is 1.8×10^{-5}, K_a for HClO is 3.5×10^{-8}.

a. NH_4ClO

Setup:

Answer: K_b for ClO^- > K_a for NH_4^+ . Basic

b. KCNO

Setup:

Answer: Basic

c. $Ni(ClO_4)_3$

Setup:

Answer: Acidic

3. What is the pH at the equivalence point when 27.0 ml of 0.200 M CH_3NH_2 are titrated with 0.350 M HCl? K_b for CH_3NH_2 is 4.4×10^{-4}.

Setup:

Answer: 5.76

4. How many ml of 0.250 M HF (aq) must be added to 500.0 ml of 0.300 M NaF to give a buffer of pH= 3.50? K_a for HF is 6.8×10^{-4} .

Setup:

Answer: 282 ml

5. Find the pH of a solution made by mixing 25.0 ml of 0.0650 M benzylamine, $C_7H_7NH_2$, and 13.9 ml of 0.0500 M HCl. K_b for $C_7H_7NH_2$ is 4.7×10^{-10} .

Setup:

Answer: 4.80

6. A chemist wants to prepare a buffer of pH = 4.35. How many milliliters of 0.455 M acetic acid must be added to 465 ml of 0.0941 M NaOH solution to obtain such a buffer? Ka for $HC_2H_3O_2$ is 1.7×10^{-5}.

Setup:

Answer: 351 ml

7. a. Is $NaHC_2O_4$ (aq) a buffer? You must show your work to prove that your answer is not a guess.
Setup:

Answer: Yes

b. Is $NaHC_2O_4$ (aq) acidic, basic, or neutral? K_{a1} for $H_2C_2O_4$ is 5.6×10^{-2}, K_{a2} for $HC_2O_4^-$ is 5.1×10^{-5}. You must show your work to justify your answer.
Setup:

Answer: K_{a2} for $HC_2O_4^-$ > Kb for $HC_2O_4^-$, Acidic