IN-CLASS PROBLEM SETS – SEPARATION SCIENCE
CHEMICAL EQUILIBRIUM UNIT

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In-class problem set #1

1. Calculate the pH of a solution that is 0.155 M in ammonia.

2. Calculate the pH of a solution that is 0.147 M in pyridine and 0.189 M in pyridinium chloride.

3. Calculate the pH of a solution that is 0.332 M in anilinium iodide.

4. Calculate the pH of a solution that is prepared by mixing 45 ml of 0.224 M chlorobenzoic (3-) acid with 30 ml of 0.187 M ethylamine.

5. Calculate the pH of a solution that is prepared by mixing 75 ml of 0.088 M aniline with 50 ml of 0.097 M nitrophenol (2-).

6. What is the typical range of K_a and K_b values for weak acids and bases? Which value represents the weakest and which the largest? What would be the pH of solutions 0.1 M in the acid or base at the extremes of the range?

In-class problem set # 2

1. Starting with 30 mL of a solution that is 0.1 M in butylamine, calculate the original pH, and then the pH as 5 mL increments of 0.1 M hydrochloric acid are added. Continue the series of calculations until 40 mL of acid have been added. Plot the data (pH on the y axis, volume of added acid on the x).

   Has 99.9% of the butylamine been titrated at the equivalence point?

In-class problem set #3

1. Calculate the pH of a 0.127 M solution of ascorbic acid.

2. Calculate the pH of a 0.089 M solution of sodium carbonate.

3. Calculate the pH of a solution prepared by adding 30 mL of 0.1 M hydrochloric acid to 60 mL of 0.080 M potassium malonate.

4. Calculate the pH of a solution prepared by adding 55 mL of 0.098 M sodium phosphate to 65 mL of 0.136 M phosphoric acid.

5. Calculate the pH of a 0.240 M solution of sodium bicarbonate.

In-class problem set #4

1. Calculate the concentration of free calcium(II) ion in a solution prepared with initial concentrations of calcium of 0.020 M and $EDTA^{4-}$ of 0.10 M.

2. Calculate the concentration of free calcium(II) ion in a solution prepared with initial concentrations of calcium of 0.020 M and total EDTA of 0.10 M. The solution is buffered at a pH of 2.

In-class Problem Set #5

Calculate the solubility of lead(II)phosphate under the following constraints.

SOLUBILITY: For our purposes, the solubility of a substance is defined as the moles of the solid that will dissolve in one liter of solution.

a) No other simultaneous equilibria occur.

Write two expressions for the solubility, one in terms of lead ion, the other in terms of phosphate ion.

b) Now the solution is at pH 3, and you need to consider the protonation of phosphate that can occur.

Write two expressions for the solubility, one in terms of lead ion, the other in terms of phosphate species.

c) Now you realize for the solution in part (b) that lead can form soluble hydroxide complexes. Incorporate these into the expression.

Write two expressions for the solubility, one in terms of lead species, the other in terms of phosphate species.

d) Revisit problem (a). What is the actual solubility of lead phosphate in unbuffered water given that other equilibria will simultaneously occur?