Worksheet 6

1. A 7.0 mass % solution of H_3PO_4 in water has a density of 1.0353 g / mL. Calculate the pH and the concentrations of all species present (H_3PO_4, $H_2PO_4^-$, HPO_4^{2-}, PO_4^{3-}, H_3O^+, and OH^-) in the solution. You will need to look up the equilibrium constants.

2. Neutralization reactions involving either a strong acid or a strong base go essentially to completion, and therefore we must take such neutralizations into account before calculating concentrations in mixtures of acids and bases. Consider a mixture of 3.28 g of Na_3PO_4 and 300.0 mL of 0.180 M HCl. Write balanced net ionic equations for the neutralization reactions, and calculate the pH of the solution.

3. A 1.000 L sample of HF gas at 20.0°C and 0.601 atm pressure was dissolved in enough water to make 50.0 mL of hydrofluoric acid. What is the pH of the solution?

4. Ethylenediamine ($NH_2CH_2CH_2NH_2$, abbreviated en) is an organic base that can accept protons:

$\text{en}(aq) + H_2O(l) \leftrightharpoons \text{enH}^+(aq) + OH^-(aq)$ $\qquad K_{b1} = 5.2 \times 10^{-4}$

$\text{enH}^+(aq) + H_2O(l) \leftrightharpoons \text{enH}_2^{2+}(aq) + OH^-(aq)$ $\qquad K_{b2} = 3.7 \times 10^{-7}$

Consider the titration of 30.0 mL of 0.100 M ethylenediamine with 0.100 M HCl. Calculate the pH after additions of the following volumes of acid, and construct a qualitative plot of pH versus milliliters of HCl added.

(a) 0.0 mL **(b)** 15.0 mL **(c)** 30.0 mL **(d)** 45.0 mL **(e)** 60.0 mL **(f)** 75.0 mL

5. A 40.0 mL sample of a mixture of HCl and H_3PO_4 was titrated with 0.100 M NaOH. The first equivalence point was reached after 88.0 mL of base, and the second equivalence point was reached after 126.4 mL of base.

(a) What is the concentration of H_3O^+ at the first equivalence point?

(b) What are the initial concentrations of HCl and H_3PO_4 in the mixture?

(c) What percent of the HCl is neutralized at the first equivalence point?

(d) What is the pH of the mixture before addition of any base?

(e) Sketch the pH titration curve, and label the buffer regions and equivalence points.

(f) What indicators would you select to signal the equivalence points?

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6. In qualitative analysis, Ca^{2+} and Ba^{2+} are separated from Na^{+}, K^{+}, and Mg^{2+} by adding aqueous $(NH_4)_2CO_3$ to a solution that also contains aqueous NH_3. Assume that the concentrations after mixing are 0.080 M $(NH_4)_2CO_3$ and 0.16 M NH_3.

(a) List all the Bronsted-Lowry acids and bases present initially, and identify the principal reaction.

(b) Calculate the pH and the concentrations of all species present in the solution.