General Chemistry II

RR #9 Answer Key

Summer 2022

1. **Are the solutions of the following salts acidic, basic, or neutral? For those which are not neutral, write balanced chemical equations for the reactions causing the solution to be acidic or basic.**

   a. **$NaNO_3$** neutral
   b. **$NaNO_2$** basic, $NO_2^-(aq) + H_2O(l) \leftrightarrow HNO_2(aq) + OH^-(aq)$
   c. **NH_4NO_3** acidic, $NH_4^+(aq) + H_2O(l) \leftrightarrow NH_3(aq) + H_3O^+(aq)$
   d. **NH_4NO_2** acidic, NH_4^+ and NO_2^- both react with water to create hydronium and hydroxide ions, respectively, but because K_b of NH_3 is smaller than K_a of HNO_2, the conjugate acid of NH_3 is a stronger acid than the conjugate base of HNO_2 is a base. Therefore, the dominating reaction is $NH_4^+(aq) + H_2O(l) \leftrightarrow NH_3(aq) + H_3O^+(aq)$, making the solution acidic.

2. **Acrylic acid (CH_2=CHCOOH) is a precursor for many important plastics. The K_a for acrylic acid is 5.6×10^{-5}.**

   a. **Calculate the pH of a 0.10 M solution of acrylic acid. x is negligible.**

	[CH_2=CHCOOH]	[CH_2=CHCOO-]	[H_3O^+]
I	0.10 M	0	0
C	-x	+x	+x
E	0.10 – x	x	x

$$K_a = 5.6 * 10^{-5} = \frac{[C_3H_3O_2^-][H_3O^+]}{[C_3H_4O_2]} = \frac{x^2}{0.10 - x}$$

$$x = 2.37 * 10^{-3} M$$

$$pH = -log([H_3O^+]) = -log(2.37 * 10^{-3}) = \mathbf{2.63}$$

   b. **Calculate the percent dissociation of a 0.10 M solution of acrylic acid**

$$\frac{2.37 * 10^{-3} M}{0.10\ M} * 100\% = 2.4\%$$

   c. **Calculate the pH of a 0.050 M solution of sodium acrylate (CH_2=CHCOONa). x is negligible.**

Na+ is a terrible acid, so we don't have to worry about it. All we need to think about is CH_2=CHCOO-'s behavior. We know it is a base because it is the product of acrylic acid dissociating in water. Its K_b is $K_W/K_a = 1.79 \times 10^{-10}$. X is negligible.

	[CH_2=CHCOO-]	[CH_2=CHCOOH]	[OH-]
I	0.050 M	0	0
C	-x	+x	+x
E	0.050 – x	x	x

$$K_b = 1.79 * 10^{-10} = \frac{[C_3H_4O_2][OH^-]}{[C_3H_3O_2^-]} = \frac{x^2}{0.050 - x}$$

$$x = 3.0 * 10^{-6} M$$

$$pOH = -\log([OH^-]) = -\log(3.0 * 10^{-6} M) = 5.52$$

$$pH = 14 - pOH = 14 - 5.52 = \mathbf{8.48}$$

3. **Indicate whether each of the following statements is correct or incorrect**

(**T** / F) **Every Bronsted-Lowry base is also a Lewis base.** To accept a proton, a molecule needs an electron pair.

(T / **F**) **Every Lewis acid is a Bronsted-Lowry acid.** Fe^{3+} is a Lewis acid, but doesn't have protons and therefore is not a BL acid.

(**T** / F) **Conjugate acids of weak bases produce more acidic solutions than conjugate acids of strong bases.** The stronger the base, the weaker the conjugate acid because of the $K_aK_b = K_w$ relationship.

(T / **F**) **The K+ ion is acidic in water because it causes hydrating water molecules to become acids.** K+ has no acidic properties.

4. **An unknown salt is either NaF, NaCl, or NaOCl. When 0.050 mol of the salt is dissolved in water to form 0.500 L of solution, the pH of the solution is 8.08. What is the identity of the salt?** ***K_a of HF = 7.2 x 10^{-4} , K_a of HCl = Large , K_a of HOCl = 3.5 x 10^{-8}*. X is <u>*not*</u> negligible.**

Right away, we can tell that NaCl is not an option because the pH of the solution is not neutral.

Since F- and OCl- are bases, they will react with water to produce OH-. Therefore, [OH-] is the concentration of interest to determine the identity of the salt, since the two bases will react with water to create different concentrations of hydroxide and result in different pHs.

$$Mystery\ Base + H_2O \leftrightarrow Mystery\ Conjugate\ Acid + OH^-$$

$$[OH^-] = 10^{14-pH} = 1.20 * 10^{-6} M$$

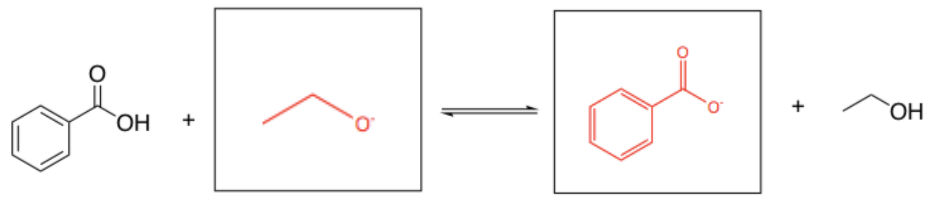
The next step is simply to use $[OH^-]$ to calculate K_b. The K_b should match that of the appropriate conjugate base. For F-, it is 1.44 x 10^{-11} and for OCl-, it is 2.86 x 10^{-7}. The equation below would result from setting up an ICE table, which I've omitted.

$$K_b = \frac{[Mystery\ Conjugate\ Acid][OH^-]}{[Mystery\ Base]} = \frac{x^2}{0.1 - x} = \frac{(1.20 * 10^{-6})^2}{0.1 - (1.20 * 10^{-6})}$$

$$= 1.44 * 10^{-11}, so\ NaF$$

5. **For the following acid-base equilibria:**

a) Complete the equation by drawing the necessary structures in each of the boxes.
b) Identify the acid, base, conjugate acid and conjugate base.
c) Determine which side of the equilibria would be favored.



Acid Base C.B. C.A.

The product side is favored. The conjugate base is charged but resonance stabilized, but the base is not, making it very unstable. The C.A. is quite stable. Looking at the pK_as verifies this. Ethanol (the C.A.) has a pK_a of 16 and benzoic acid (the acid) has a pK_a of 4.20.