General Chemistry II

RR #7 Answer Key
Summer 2022

1. **Given that the K_a for acetic acid, CH_3COOH, is 1.8×10^{-5} , calculate the pH of a 0.20 mol/L solution. Assume x is negligibly small compared to the original concentration of acetic acid.**

Use an ICE chart.

Equation	**$[CH_3COOH]$**	**H_2O**	**$[CH_3COO^-]$**	**$[H_3O^+]$**
I	0.20	N/A	0	0
C	-x	N/A	+x	+x
E	0.20 - x	N/A	x	x

$$K_a = 1.8 * 10^{-5} = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]} = \frac{x^2}{0.20\ M}$$

$$x = 1.9 * 10^{-3} M\ H_3O^+$$

$$pH = -log([H_3O^+]) = -log(1.9 * 10^{-3} M) = 2.72$$

2. **A student prepares a 0.45 M solution of a monoprotic weak acid and determines the pH to be 3.68. What is the K_a of this weak acid? . Assume x is negligibly small compared to the original concentration of acid.**

Equation	[HA]	H_2O	[A-]	$[H_3O^+]$
I	0.45	N/A	0	0
C	-x	N/A	+x	+x
E	0.45 - x	N/A	x	x

But what is x?

$$-log([H_3O^+]) = pH, \text{ so } 10^{-pH} = [H_3O^+] \; and \; [A^-]$$

$$10^{-3.68} = 2.09 * 10^{-4} \; M$$

So…

$$K_a = \frac{[A^-][H_3O^+]}{[HA]} = \frac{(2.09 * 10^{-4} \; M)^2}{0.45 \; M} = 9.71 * 10^{-8}$$

3. **The value of K_w depends on temperature. At body temperature (37ºC), $K_w = 2.4 \times 10^{-14}$**
   a. **What is the $[H_3O+]$ of pure water at body temperature?**

$$\boldsymbol{[H_3O^+] = \sqrt{K_W} = \sqrt{2.4 * 10^{-14}} = 1.55 * 10^{-7} M}$$

   b. **What is the [OH-] of pure water at body temperature?**

$$\boldsymbol{[OH^-] = [H_3O^+] = 1.55 * 10^{-7} M}$$

   c. **What is the pH of pure water at body temperature?**

$$\boldsymbol{-log([H_3O^+]) = -log(1.55 * 10^{-7} M) = 6.81}$$

   d. **What is the pOH of pure water at body temperature?**

$$\boldsymbol{-log([OH^-]) = -log(1.55 * 10^{-7} M) = 6.81}$$

4. **Calculate [H+] for each of the following solutions, and indicate whether the solution is acidic, basic, or neutral:**

   a. **[OH-] = 0.00045 M**

   $K_W = 10^{-14}$
   $[H+] = Kw / [OH-] = 10^{-14} / 0.00045 =$ **2.2×10^{-11} M**
   $pH = -\log([H+]) = -\log(2.2 \times 10^{-11}\ M) = 10.65$, **BASIC**

   b. **[OH-] = 8.8×10^{-9} M**

   $K_W = 10^{-14}$
   $[H+] = Kw / [OH-] = 10^{-14} / 8.8 \times 10^{-9} =$ **1.1×10^{-6} M**
   $pH = -\log([H+]) = -\log(1.1 \times 10^{-6}\ M) = 5.94$, **ACIDIC**

   c. **A solution in which [OH-] is 100 times greater than [H+]**

   $K_W = 10^{-14}$
   $= [OH-][H+]$
   $= 100x^2$
   $x = [H+] =$ **10^{-8} M**
   $pH = -\log([H+]) = -\log(10^{-8}\ M) = 8$, **BASIC**

MCAT Style Questions

5. **By what factor does [H+] change for a pH change of 2.00 units?**

   a. **2**
   b. **100**
   c. **200**
   d. **2000**

6. **The conjugate acid of the $H_2SiO_4^{2-}$ (dihydrogen orthosilicate) anion is:**

   a. **$H_2SiO_4^{2-}$**
   b. **$H_3SiO_4^-$**
   c. **H_4SiO_4**
   d. **H_3O^+**

7. **The first step of a nitration reaction involves using a mixture of sulfuric acid and nitric acid to form an NO_2^+ electrophile, as shown below.**

$$H_2SO_4 + HNO_3 \longleftrightarrow HSO_4^- + H_2NO_3^+ \longleftrightarrow HSO_4^- + H_2O + NO_2^+$$

In the forward reaction of the equilibrium, which of the following molecules acts as a Bronsted-Lowry base?

a. H_2SO_4
b. HNO_3
c. HSO_4^-
d. $H_2NO_3^+$

8. **Hypochlorous acid dissociates in water to create hydronium ions and hypochlorite ions: $HOCl + H_2O \longleftrightarrow H_3O^+ + OCl^-$. Suppose that additional hypochlorite ions are added to the solution. Which of the following correctly describes the resultant effect on the concentration of HOCl?**

a. It depends on the number of hydronium ions
b. It remains the same
c. It increases
d. It decreases

9. **Suppose a large organic molecule X is classified as a Lewis acid, while another large molecule Y is classified as a Bronsted-Lowry acid. Which of the following most accurately describes a similarity in their behaviors in solution?**

a. Both molecules will tend to acquire a net positive charge
b. Both molecules will release hydroxide ions
c. Both molecules will release hydrogen gas
d. Both molecules will tend to acquire a net negative charge

10. **Suppose an equilibrated, dilute solution containing an acid HA with $K_a = 10^{-4}$ is measured to have pH = 6 and [HA] = 10^{-8} M. Which of the following gives the best estimate of $[A^-]$?**

a. 10^{-4}
b. 10^{-6}
c. 10^{-14}
d. 10^{-16}