Now you try!

1. What is the pH of a 0.200 M solution of HNO_2? The K_a of HNO_2 is 4.6 x 10^{-4}.

$$HNO_{2(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + NO_2^-{}_{(aq)}$$

$$K_a = \frac{[H_3O^+][NO_2^-]}{[HNO_2]} = \frac{x^2}{0.200 - x} \approx \frac{x^2}{0.200} = 4.6E-4$$

$K_a << 1$, x negligible

$$x = [H_3O^+] = \sqrt{(0.200)(4.6E-4)} = 9.6E-3\ M$$

$$pH = -\log[H_3O^+] = -\log(9.6E-3) = \boxed{2.02}$$

2. The carbonate ion, CO_3^{2-}, is a weak base (K_b = 2.13 x 10^{-4}). Calculate the pH of a 1.3 M carbonate solution.

$$CO_3^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HCO_3^-{}_{(aq)} + OH^-_{(aq)}$$

$$K_b = \frac{[HCO_3^-][OH^-]}{[CO_3^{2-}]} = \frac{x^2}{1.3 - x} \approx \frac{x^2}{1.3} = 2.13E-4$$

$K_b << 1$, x negligible

$$x = [OH^-] = \sqrt{(1.3)(2.13E-4)} = 0.017\ M$$

$$pOH = -\log[OH^-] = -\log(0.017) = 1.78$$

$$\Rightarrow pH = 14 - pOH = 14 - 1.78 = \boxed{12.22}$$

3. The pH of a 0.010 M solution of benzoic acid, C_6H_5COOH (a monoprotic acid), is 3.09. What is the ionization constant for benzoic acid?

$$[H_3O^+] = 10^{-pH} = 10^{-3.09} = 8.1 \times 10^{-4}\ M = x$$

$$C_6H_5COOH\,(aq) + H_2O\,(l) \rightleftharpoons H_3O^+\,(aq) + C_6H_5COO^-\,(aq)$$

$$K_a = \frac{[H_3O^+][C_6H_5COO^-]}{[C_6H_5COOH]} = \frac{x^2}{0.010 - x} = \frac{(8.1\,E{-4})^2}{0.010 - 8.1\,E{-4}} = \boxed{7.1 \times 10^{-5}}$$

Multiple Choice Practice

1. Which of the following could be added to an aqueous solution of the weak acid HF to increase the percent dissociation?

   a. NaF(s) (b.) $H_2O(l)$ c. NaOH(s) d. $NH_3(aq)$

   increase $H_2O \Rightarrow \downarrow [HF] = \uparrow$ % Ion

2. Which of the following solutions will have the highest pH? $\uparrow pH = \downarrow [H_3O^+]$

   ~~a.~~ 0.20 M HCl ~~b.~~ 0.10 M HCl ~~c.~~ 0.20 M $HC_2H_3O_2$ (d.) 0.10 M $HC_2H_3O_2$

   Strong acid $= \uparrow [H_3O^+]$

3. A weak monoprotic acid has an ionization constant of 1.0×10^{-8}. What will be the percent dissociation of the acid in a 4.0-molar solution?

   a. 0.8% b. 0.05% (c.) 0.005% d. 0.0002%

$$K_a = \frac{x^2}{[HA]} = \frac{x^2}{4.0} = 1.0\,E{-8}$$

$$\Rightarrow x = [H_3O^+] = \sqrt{(4.0)(1.0\,E{-8})} = 2.0 \times 10^{-4}\ M$$

$$\%\ Diss = \frac{[H_3O^+]_{eq}}{[HA]_i} \times 100 = \frac{2.0\,E{-4}}{4.0} \times 100 = \boxed{0.0050\%}$$

4. Which of the following solutions has the greatest percent ionization?

a. 0.20 M $HC_2H_3O_2$ b. 0.10 M $HC_2H_3O_2$ c. 0.050 M $HC_2H_3O_2$ (d.) 0.010 M $HC_2H_3O_2$

★ all the same weak acid $\downarrow [HA] = \uparrow \%$ Ion.

5. A weak monoprotic acid, HA, has a pH of 5.00 when [HA] = 0.25 M. Calculate the ionization constant of this acid.

a. 2.5×10^{-5} b. 2.5×10^{-10} (c.) 4.0×10^{-10} d. 4.0×10^{-11}

$$[H_3O^+] = 10^{-pH} = 10^{-5.00} = 1.0 \times 10^{-5}\ M = x$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]} = \frac{x^2}{0.25} = \frac{(1.0E-5)^2}{0.25} = \boxed{4.0 \times 10^{-10}}$$

6. Acetic acid has an ionization constant that is approximately equal to 2.0×10^{-5}. What will be the percent dissociation of acetic acid in a 0.20 M solution?

(a.) 1.0% b. 0.20% c. 0.010% d. 0.0020%

$$K_a = \frac{x^2}{[HA]} = \frac{x^2}{0.20} = 2.0E-5$$

$$x = [H_3O^+] = \sqrt{(0.20)(2.0E-5)} = 2.0 \times 10^{-3}\ M$$

$$\%\ Diss = \frac{[H_3O^+]_{eq}}{[HA]_i} \times 100 = \frac{2.0E-3}{0.20} \times 100 = \boxed{1.0\%}$$

7. Which of the following solutions has the smallest percent ionization?

(a.) 0.20 M HNO_2 b. 0.10 M HNO_2 c. 0.20 M HNO_3 d. 0.10 M HNO_3

$\uparrow [HA] = \downarrow \%$ Ion (of a weak acid)

100% ionization! (strong acid ☺)

8. A 1-molar solution of a very weak monoprotic acid has a pH of 5. What is the value of K_a for the acid?

(a.) 1×10^{-10} b. 1×10^{-7} c. 1×10^{-5} d. 1×10^{-2}

$$[H_3O^+] = 10^{-pH} = 10^{-5} = x$$

$$K_a = \frac{x^2}{[HA]} = \frac{(10^{-5})^2}{1} = \boxed{10^{-10}}$$