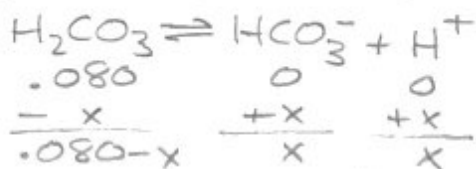
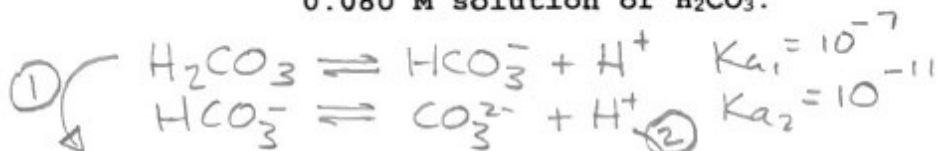


## pH of Polyprotic Acids

1. Write the ionization reactions for carbonic acid. Given that  $K_{a1} = 4.4 \times 10^{-7}$  and  $K_{a2} = 4.7 \times 10^{-11}$ , calculate the  $[H_2CO_3]$ ,  $[HCO_3^-]$ ,  $[CO_3^{2-}]$ , and the pH of a 0.080 M solution of  $H_2CO_3$ .



$$4.4 \times 10^{-7} = \frac{x^2}{.080}$$

$$x = 1.9 \times 10^{-4} M$$

$$[H^+] = [HCO_3^-] = 1.9 \times 10^{-4} M$$

$$[H_2CO_3] = .080 M$$

$$pH = -\log[(1.9 \times 10^{-4}) + (4.7 \times 10^{-11})]$$

$$= -\log 1.9 \times 10^{-4}$$

$$= 3.7$$

negligible

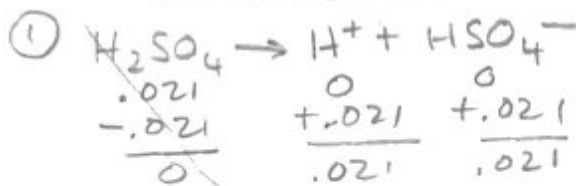


$$4.7 \times 10^{-11} = \frac{(1.9 \times 10^{-4})(x)}{1.9 \times 10^{-4} + x}$$

$$x = 4.7 \times 10^{-11} \text{ negligible}$$

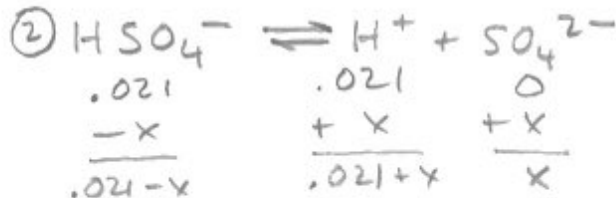
$$[CO_3^{2-}] = 4.7 \times 10^{-11} M$$

2. Write the ionization reactions for the first and second ionizations of sulfuric acid. Remember, sulfuric acid is a strong acid. Given that the  $K_a$  of  $HSO_4^-$  is  $1.1 \times 10^{-2}$ , calculate the  $[H_3O^+]$ ,  $[HSO_4^-]$ ,  $[SO_4^{2-}]$  and pH of a 0.021 M solution of sulfuric acid.



gone!

do not use 5% Rule!



$$K_{a2} = 1.1 \times 10^{-2} = \frac{(.021+x)(x)}{.021-x}$$

$$x = .0061 M$$

$$[SO_4^{2-}] = .0061 M$$

$$[HSO_4^-] = .021 - .0061 = .015 M$$

$$[H^+] = .021 + .0061 = .027 M$$

$$pH = -\log .027$$

$$= 1.57$$

3. Given that  $K_{a1} = 6.5 \times 10^{-2}$  and  $K_{a2} = 6.1 \times 10^{-5}$ , calculate the pH of a 1.40 M  $H_2C_2O_4$  (oxalic acid) solution and the equilibrium concentrations of  $H_2C_2O_4$ ,  $HC_2O_4^-$ ,  $C_2O_4^{2-}$ , and  $OH^-$ .



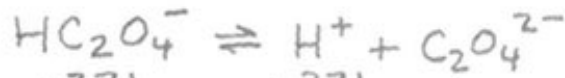
$$\begin{array}{ccc} 1.40 & 0 & 0 \\ -x & +x & +x \\ \hline 1.40-x & x & x \end{array}$$

$$6.5 \times 10^{-2} = \frac{(x)(x)}{1.40-x}$$

$$x = .271 \text{ M}$$

$$[H^+] = [HC_2O_4^-] = .271 \text{ M}$$

$$[H_2C_2O_4] = 1.40 - .271 = 1.13 \text{ M}$$



$$\begin{array}{ccc} .271 & .271 & 0 \\ -x & +x & +x \\ \hline .271-x & .271+x & x \end{array}$$

$$6.1 \times 10^{-5} = \frac{(.271)(x)}{.271}$$

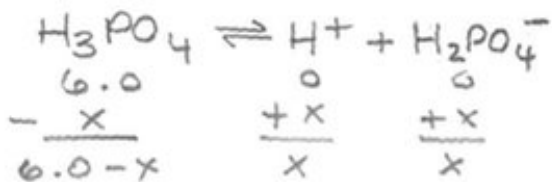
$$x = 6.1 \times 10^{-5} \text{ M}$$

$$[C_2O_4^{2-}] = 6.1 \times 10^{-5} \text{ M}$$

$$pH = -\log .271 = .567$$

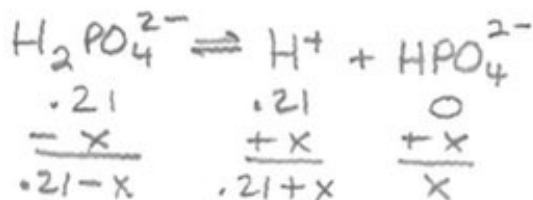
$$[OH^-] = \frac{K_w}{[H^+]} = \frac{1 \times 10^{-14}}{.271} = 3.7 \times 10^{-14} \text{ M } OH^-$$

4. Calculate the  $[H_2PO_4^-]$ ,  $[HPO_4^{2-}]$ ,  $[PO_4^{3-}]$ ,  $[OH^-]$ , and pH of a 6.0 M phosphoric acid solution.  $K_{a1} = 7.5 \times 10^{-3}$ ,  $K_{a2} = 6.2 \times 10^{-8}$ , and  $K_{a3} = 4.8 \times 10^{-13}$ .



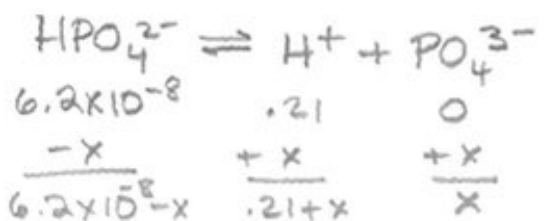
$$7.5 \times 10^{-3} = \frac{x^2}{6.0-x}$$

$$x = .208 = .21 \text{ M} = [H^+] = [H_2PO_4^-]$$



$$6.2 \times 10^{-8} = \frac{(.21)(x)}{.21}$$

$$x = 6.2 \times 10^{-8} \text{ M} = [HPO_4^{2-}]$$



$$4.8 \times 10^{-13} = \frac{(.21)(x)}{6.2 \times 10^{-8}}$$

$$x = 1.4 \times 10^{-19} \text{ M} = [PO_4^{3-}]$$

$$pH = -\log .21 = .68$$

$$[OH^-] = 10^{-13.32} = 4.8 \times 10^{-14} \text{ M}$$