

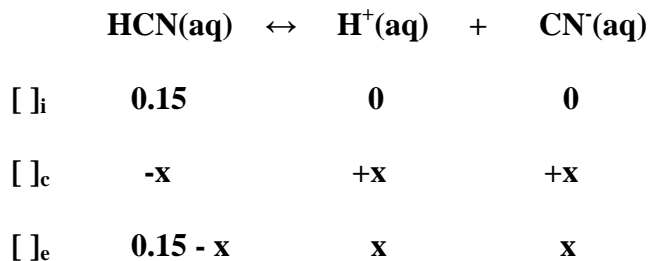
Weak Acid And Weak Base Problems

- 1) Calculate the hydronium ion concentration in a 0.15 M HCN solution.
($K_a = 4.0 \times 10^{-10}$)
- 2) What is the pH of a 0.176 M solution of sodium fluoride? ($K_b = 1.4 \times 10^{-11}$)
- 3) What is the pH of a 0.136 M solution of H_2S ? ($K_a = 1.00 \times 10^{-7}$)
- 4) What is the pH of a solution if 17.3 g of NaCN is added to 750. mL of water?
($K_b = 2.5 \times 10^{-5}$)
- 5) What is the concentration of carbonate in a 0.16 M solution of carbonic acid?
($K_{a1} = 4.2 \times 10^{-7}$, $K_{a2} = 4.8 \times 10^{-11}$)

Solutions

1) $[\text{HCN}] = 0.15 \text{ M}$ $K_a = 4.0 \times 10^{-10}$

$[\text{H}_3\text{O}^+] = [\text{H}^+] = ?$



$$K_a = [\text{H}^+] \times [\text{CN}^-] / [\text{HCN}]$$

$$4.0 \times 10^{-10} = x \cdot x / (0.15 - x) \approx x^2 / 0.15$$

$$[\text{H}^+] = 7.7 \times 10^{-6} \text{ M}$$

$$\% \text{ ion} = [\text{H}^+] / [\text{HCN}] \times 100\%$$

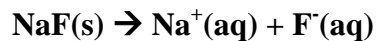
$$\% \text{ ion} = (7.7 \times 10^{-6} \text{ M}) / (0.15 \text{ M}) \times 100\% = 5.1 \times 10^{-5}\%$$

Because the % ion < 5%, $0.15 - x \approx 0.15$ is a valid assumption.

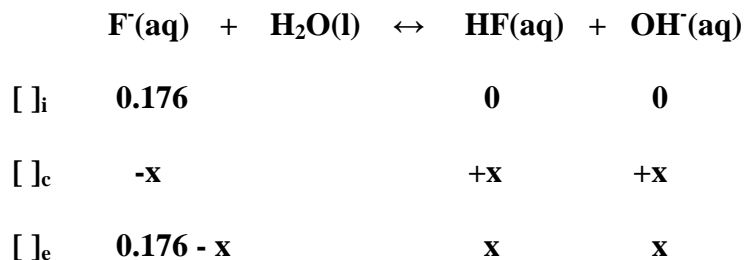
$$[\text{H}^+] = 7.7 \times 10^{-6} \text{ M}$$

2) $[\text{NaF}] = 0.176 \text{ M}$ $K_b = 1.4 \times 10^{-11}$

$\text{pH} = ?$



$[\text{F}^-] = 0.176 \text{ mol NaF/L} \times 1 \text{ mol F}^- / 1 \text{ mol NaF} = 0.176 \text{ M}$



$K_b = [\text{HF}] \times [\text{OH}^-] / [\text{F}^-]$

$1.4 \times 10^{-11} = x \cdot x / (0.176 - x) \approx x^2 / 0.176$

$[\text{OH}^-] = 1.6 \times 10^{-6} \text{ M}$

$\% \text{ ion} = [\text{HF}] / [\text{F}^-] \times 100\%$

$\% \text{ ion} = (1.6 \times 10^{-6} \text{ M}) / (0.176 \text{ M}) \times 100\% = 9.1 \times 10^{-4}\%$

Because the $\% \text{ ion} < 5\%$, $0.176 - x \approx 0.176$ is a valid assumption.

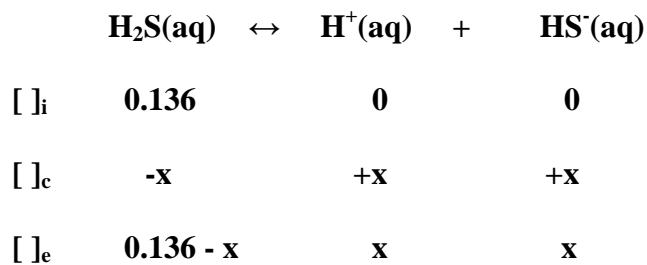
$K_w = [\text{H}^+] \times [\text{OH}^-] = 1.00 \times 10^{-14}$

$[\text{H}^+] = K_w / [\text{OH}^-] = (1.00 \times 10^{-14}) / (1.6 \times 10^{-6}) = 6.2 \times 10^{-9} \text{ M}$

$\text{pH} = -\log[\text{H}^+] = -\log(6.2 \times 10^{-9}) = \mathbf{8.21}$

3) $[\text{H}_2\text{S}] = 0.136 \text{ M}$ $K_a = 1.00 \times 10^{-7}$

$\text{pH} = ?$



$$K_a = [\text{H}^+] \times [\text{HS}^-] / [\text{H}_2\text{S}]$$

$$1.00 \times 10^{-7} = x \cdot x / (0.136 - x) \approx x^2 / 0.136$$

$$[\text{H}^+] = 1.17 \times 10^{-4} \text{ M}$$

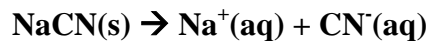
$$\% \text{ ion} = [\text{H}^+] / [\text{H}_2\text{S}] \times 100\%$$

$$\% \text{ ion} = (1.17 \times 10^{-4} \text{ M}) / (0.136 \text{ M}) \times 100\% = 8.60 \times 10^{-2}\%$$

Because the % ion < 5%, $0.136 - x \approx 0.136$ is a valid assumption.

$$\text{pH} = -\log[\text{H}^+] = -\log(1.17 \times 10^{-4}) = \mathbf{3.932}$$

4) $m = 17.3 \text{ g NaCN}$ $K_b = 2.5 \times 10^{-5}$
 $V = 750. \text{ mL}$ $\text{pH} = ?$

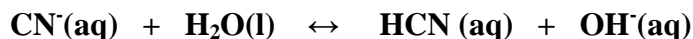


$$[\text{NaCN}] = n/V$$

$$[\text{NaCN}] = (17.3 \text{ g NaCN/L} \times 1 \text{ mol NaCN}/49.01 \text{ g NaCN}) / (750. \text{ mL} \times 1\text{L}/10^3 \text{ mL})$$

$$[\text{NaCN}] = 0.471 \text{ M}$$

$$[\text{CN}^-] = 0.471 \text{ mol NaCN/L} \times 1 \text{ mol CN}^- / 1 \text{ mol NaCN} = 0.471 \text{ M}$$



$$[\]_i \quad 0.471 \quad \quad \quad 0 \quad \quad \quad 0$$

$$[\]_c \quad -x \quad \quad \quad +x \quad \quad \quad +x$$

$$[\]_e \quad 0.471 - x \quad \quad \quad x \quad \quad \quad x$$

$$K_b = [\text{HCN}] \times [\text{OH}^-] / [\text{CN}^-]$$

$$2.5 \times 10^{-5} = x \cdot x / (0.471 - x) \approx x^2 / 0.471$$

$$[\text{OH}^-] = 3.4 \times 10^{-3} \text{ M}$$

$$\% \text{ ion} = [\text{HCN}] / [\text{CN}^-] \times 100\%$$

$$\% \text{ ion} = (3.4 \times 10^{-3} \text{ M}) / (0.471 \text{ M}) \times 100\% = 7.2 \times 10^{-1}\%$$

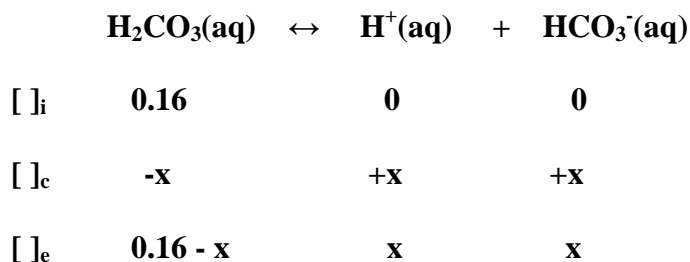
Because the % ion < 5%, $0.471 - x \approx 0.471$ is a valid assumption.

$$\text{pOH} = -\log[\text{OH}^-] = -\log(3.4 \times 10^{-3}) = 2.47$$

$$\text{pH} + \text{pOH} = 14.00$$

$$\text{pH} = 14.00 - \text{pOH} = 14.00 - 2.47 = \mathbf{11.53}$$

5) $[\text{H}_2\text{CO}_3] = 0.16 \text{ M}$ $K_{a1} = 4.2 \times 10^{-7}$
 $[\text{CO}_3^{2-}] = ?$ $K_{a2} = 4.8 \times 10^{-11}$



$$K_{a1} = [\text{H}^+] \times [\text{HCO}_3^-] / [\text{H}_2\text{CO}_3]$$

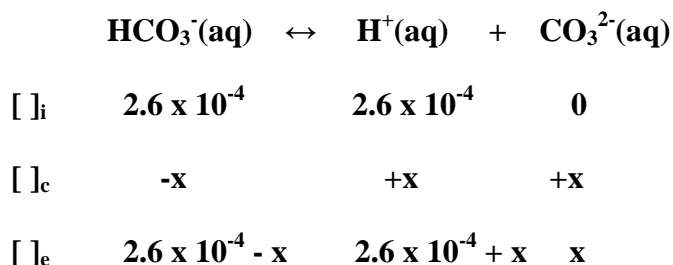
$$4.2 \times 10^{-7} = x \cdot x / (0.16 - x) \approx x^2 / 0.16$$

$$[\text{H}^+] = 2.6 \times 10^{-4} \text{ M}$$

$$\% \text{ ion} = [\text{H}^+] / [\text{H}_2\text{CO}_3] \times 100\%$$

$$\% \text{ ion} = (2.6 \times 10^{-4} \text{ M}) / (0.16 \text{ M}) \times 100\% = 1.6 \times 10^{-1}\%$$

Because the % ion < 5%, $0.16 - x \approx 0.16$ is a valid assumption.



$$K_{a2} = [\text{H}^+] \times [\text{CO}_3^{2-}] / [\text{HCO}_3^-]$$

$$4.8 \times 10^{-11} = (2.6 \times 10^{-4} + x) \cdot x / (2.6 \times 10^{-4} - x) \approx x$$

$$[\text{CO}_3^{2-}] = 4.8 \times 10^{-11} \text{ M}$$

