

#63365 Chemistry, General Chemistry

Determine the concentrations of the following ionic species present in a 0.311 M solution of the diprotic acid H_2SO_3 . For H_2SO_3 , $K_{a1} = 1.4\text{E-}2$, $K_{a2} = 6.3\text{E-}8$.

What is the H_3O^+ ion concentration?

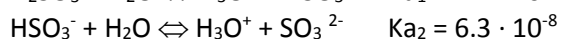
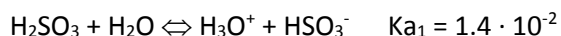
the tolerance is +/-2%

What is the HSO_3^- ion concentration?

the tolerance is +/-2%

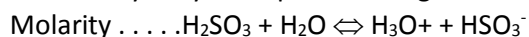
What is the SO_3^{2-} ion concentration?

Answer:



Because K_{a1} is much greater than K_{a2} , the amount of H_3O^+ produced (and the amount of HSO_3^- reacted) in Step 2 is negligible compared to the amount from Step 1.

The first hydrolysis step will undergo as follows:



Initial 0.311 0 0

Change -x x x

Equilibrium . . . 0.311-x x x

$$K_{a1} = [\text{H}_3\text{O}^+][\text{HSO}_3^-] / [\text{H}_2\text{SO}_3] = (x)(x) / (0.311-x) = 1.4 \cdot 10^{-2}$$

$$x^2 = (1.4 \cdot 10^{-2})(0.311-x)$$

$$x^2 = -0.014x + 0.0068$$

$$x^2 + 0.013x - 0.0043 = 0$$

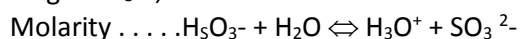
$$x = 0.072 \text{ and } -0.059$$

$$[\text{H}_2\text{SO}_3] = 0.311 - x = 0.311 - 0.072 = 0.239 \text{ M}$$

$$[\text{H}_3\text{O}^+] = [\text{HSO}_3^-] = x = 0.072 \text{ M}$$

$$\text{Since } [\text{H}_3\text{O}^+][\text{OH}^-] = 1.0 \times 10^{-14}, \text{ then } [\text{OH}^-] = (1.0 \cdot 10^{-14} / 0.072) = 1.4 \cdot 10^{-13}$$

To get SO_3^{2-} , we need to look at the second reaction.



Initial 0.072 0.072 . . 0

Change -x x x

Equilibrium . . . 0.072-x 0.072+x . . x

$$K_{a2} = [\text{H}_3\text{O}^+][\text{SO}_3^{2-}] / [\text{HSO}_3^-] = (0.072+x)(x) / (0.072-x) = 6.3 \times 10^{-8}$$

As K_{a2} is small (10^{-8}), then the x term will be small compared to 0.072 and we can drop it from 0.072-x and 0.072+x.

$$0.072x / 0.072 = x = 6.3 \times 10^{-8}$$

$$[\text{SO}_3^{2-}] = x = K_{a2} = 6.3 \times 10^{-8}$$