Answer on the question #63364, Chemistry / General Chemistry

Question :

Determine the concentrations of the ionic species present in a 0.00222 M solution of the H2SO3. (pKa1 = 1.85, pKa2 = 7.20).
[H2SO3] M, [HSO3-] M, [SO32-]M, [H3O+] M, [OH-] M

Solution:

The dissociation steps are:

$$\text{I.}\ H_2SO_3 \rightarrow H^+ + HSO_3^-$$
$$\text{II.}\ HSO_3^- \rightarrow H^+ + SO_3^{2-}.$$

The relation for equilibrium constants:

$$K_{a1} = \frac{[HSO_3^-][H^+]}{[H_2SO_3]}$$
$$K_{a2} = \frac{[SO_3^{2-}][H^+]}{[HSO_3^-]}$$

As pKa_2 is much bigger than pKa_1, we can assume that the dissociation by second stage is merely marginal. Then:

$$[HSO_3^-] = [H^+] = x$$
$$[H_2SO_3] = 0.00222 - x$$

$$K_{a1} = \frac{x^2}{0.00222 - x} = 10^{-1.85}$$

$$x = \ 0.001953\ M$$
$$[HSO_3^-] = [H^+] = 0.001953\ M;\ [H_2SO_3] = 0.00222 - x = 0.000267\ M.$$

Then, taking the concentration of HSO_3^-, H^+ we calculate small dissociation for the second stage:

$$K_{a2} = \frac{[SO_3^{2-}][H^+]}{[HSO_3^-]}$$
$$[SO_3^{2-}] = K_{a2} \cdot \frac{[HSO_3^-]}{[H^+]}$$
$$[SO_3^{2-}] = 10^{-7.20} = 6.3 \cdot 10^{-8} M.$$

Now we see, that our assumption was correct, sulfite anion concentration is really much lower.
Let's calculate the concentration of hydroxide anion:

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

$$[OH^-] = \frac{10^{-14}}{[H^+]} = 5.12 \cdot 10^{-12}$$

Answer: $[HSO_3^-] = [H^+] = 0.001953\ M$, $[H_2SO_3] = 0.000267\ M$, $[SO_3^{2-}] = 6.3 \cdot 10^{-8} M$, $[OH^-] = 5.12 \cdot 10^{-12}\ M$.

Remark: of course, H_3O^+ and H^+ cation is the same (not exactly, but in the meaning of concentration), we just used H^+ notation to make clearer calculations. You can take the concentration of H+, obtained here and use it as a concentration of H_3O^+.

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