CONCEPT: POLYPROTIC ACIDS

Our understanding of diprotic acids and bases can be used to understand polyprotic acids and bases.

For polyprotic acids _____ their equations can be illustrated by:

$H_3A\,(aq) + H_2O\,(l) \rightleftharpoons H_2A^-\,(aq) + H_3O^+\,(aq)$ $\quad K_{a1} = \dfrac{\text{Products}}{\text{Reactants}} =$

$H_2A^-\,(aq) + H_2O\,(l) \rightleftharpoons HA^{2-}\,(aq) + H_3O^+\,(aq)$ $\quad K_{a2} = \dfrac{\text{Products}}{\text{Reactants}} =$

$HA^{2-}\,(aq) + H_2O\,(l) \rightleftharpoons A^{3-}\,(aq) + H_3O^+\,(aq)$ $\quad K_{a3} = \dfrac{\text{Products}}{\text{Reactants}} =$

For polyprotic bases _____ their equations can be illustrated by:

$A^{3-}\,(aq) + H_2O\,(l) \rightleftharpoons HA^{2-}\,(aq) + OH^-\,(aq)$ $\quad K_{b1} = \dfrac{\text{Products}}{\text{Reactants}} =$

$HA^{2-}\,(aq) + H_2O\,(l) \rightleftharpoons H_2A^-\,(aq) + OH^-\,(aq)$ $\quad K_{b2} = \dfrac{\text{Products}}{\text{Reactants}} =$

$H_2A^-\,(aq) + H_2O\,(l) \rightleftharpoons H_3A\,(aq) + OH^-\,(aq)$ $\quad K_{b3} = \dfrac{\text{Products}}{\text{Reactants}} =$

As a result of these equations for polyprotic acids and bases the relationship between K_a and K_b will be:

$$K_{a1} \cdot K_{b3} = K_w \qquad K_{a2} \cdot K_{b2} = K_w \qquad K_{a3} \cdot K_{b1} = K_w$$

When dealing with polyprotic acids:

- H_3A can be treated as a monoprotic acid and we use _____ can be used to find pH.
- A^{3-} represents the basic form and we use _____ can be used to find pH.

H_2A^- $\quad [H^+] \approx \sqrt{\dfrac{K_{a1}K_{a2}[\,]_0 + K_{a1}K_w}{K_{a1} + [\,]_0}}$ $\qquad$ HA^{2-} $\quad [H^+] \approx \sqrt{\dfrac{K_{a2}K_{a3}[\,]_0 + K_{a2}K_w}{K_{a2} + [\,]_0}}$

PRACTICE: POLYPROTIC ACID CALCULATIONS 1

EXAMPLE 1: Calculate the equilibrium concentrations of H_3PO_4, $H_2PO_4^-$, HPO_4^{2-}, PO_4^{3-}, and H_3O^+ for 0.35 M H_3PO_4.

$Ka_1 = 7.2 \times 10^{-3}$, $Ka_2 = 6.3 \times 10^{-8}$, and $Ka_3 = 4.2 \times 10^{-13}$.

PRACTICE: POLYPROTIC ACID CALCULATIONS 2

EXAMPLE 1: Determine the pH of 0.250 M sodium hydrogen phosphate, Na_2HPO_4. Phosphoric acid, H_3PO_4, contains K_{a1} = 7.5×10^{-3}, K_{a2} = 6.2×10^{-8} and K_{a3} = 4.2×10^{-13}.

EXAMPLE 2: Determine the pH of 0.150 M citric acid, $H_3C_6H_5O_7$. It possesses K_{a1} = 7.4×10^{-4}, K_{a2} = 1.7×10^{-5} and K_{a3} = 4.0×10^{-7}.