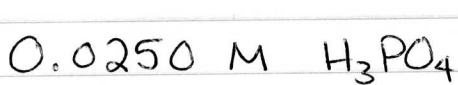


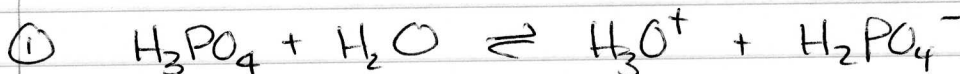
Ch. 16 Additional Problem



$$K_{a1} = 7.5 \times 10^{-3}$$

$$K_{a2} = 6.2 \times 10^{-8}$$

$$K_{a3} = 4.2 \times 10^{-13}$$



i 0.0250 M lots 0 0

Δ -x +x +x

eq. 0.0250 - x x x

$$K_{a1} = \frac{x^2}{0.0250 - x} = 7.5 \times 10^{-3}$$

$$\frac{[\text{HA}]}{K_a} = \frac{0.0250}{7.5 \times 10^{-3}} = 3.33$$

not ok to neglect x

Use successive approximations,

① neglect x $\frac{x^2}{0.0250} = 7.5 \times 10^{-3}$ $x^2 = (0.0250)(7.5 \times 10^{-3})$

$$x_1 = \sqrt{(7.5 \times 10^{-3})(0.0250)} = 0.01369 \text{ M}$$

$$x_2 = \sqrt{K_a(0.0250 - x_1)} = 9.2 \times 10^{-3} \text{ M}$$

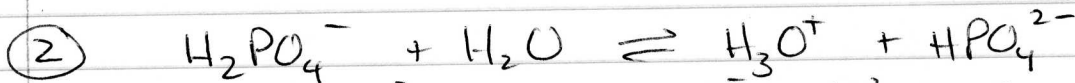
$$x_3 = \sqrt{K_a(0.0250 - x_2)} = 1.088 \times 10^{-2} \text{ M}$$

$$x_4 = 1.0289 \times 10^{-2} \text{ M}$$

$$x_5 = 1.05 \times 10^{-2}$$

$$x_6 = 1.042 \times 10^{-2}$$

close enough!
(could have stopped sooner...)



i 1.042×10^{-2} lots $1.042 \times 10^{-2} \text{ M}$ 0

Δ -y +y +y

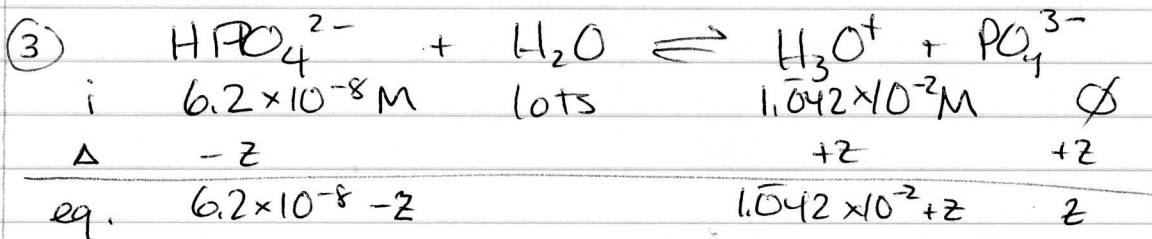
eq. $1.042 \times 10^{-2} - y$ $1.042 \times 10^{-2} \text{ M} + y$ y

$$K_{a2} = \frac{(1.042 \times 10^{-2} + y)(y)}{(1.042 \times 10^{-2} - y)} = 6.2 \times 10^{-8} \leftarrow \text{very small}$$

neglect y's

$$K_{a2} = \frac{(1.042 \times 10^{-2})(y)}{(1.042 \times 10^{-2})}$$

$$y = K_{a2} = 6.2 \times 10^{-8}$$



$$K_{a3} = \frac{(1.042 \times 10^{-2} + z)(z)}{(6.2 \times 10^{-8} - z)} = 4.2 \times 10^{-13}$$

K_{a3} very small.
 z is very small,
 ok to neglect.

$$K_{a3} = \frac{(1.042 \times 10^{-2})(z)}{6.2 \times 10^{-8}} = 4.2 \times 10^{-13}$$

$$\text{so } z = \frac{(4.2 \times 10^{-13})(6.2 \times 10^{-8})}{(1.042 \times 10^{-2})} = 2.497 \times 10^{-18}$$

$$[\text{H}_3\text{PO}_4] = 0.0250 - 0.01042 = 0.01458 = 0.015 \text{ M } \text{H}_3\text{PO}_4$$

$$[\text{H}_2\text{PO}_4^-] = x = 0.010 \text{ M}$$

$$[\text{HPO}_4^{2-}] = y = 6.2 \times 10^{-8} \text{ M}$$

$$[\text{PO}_4^{3-}] = z = 2.5 \times 10^{-18} \text{ M}$$

$$[\text{H}_3\text{O}^+] = 0.010 \text{ M}$$

$$[\text{OH}^-] = \frac{K_w}{[\text{H}_3\text{O}^+]} = \frac{1.0 \times 10^{-14}}{0.01042} = 9.6 \times 10^{-13} \text{ M } \text{OH}^-$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+] = -\log (0.01042) = 1.98$$