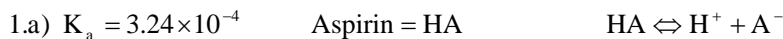


Chemistry 255
 Spring 2011
 Problem Set #3
 Answer Key



$$K_a = \frac{[H^+][A^-]}{[HA]} = \frac{x^2}{(0.492 - x)} = 3.24 \times 10^{-4} \text{ since } [H^+] = [A^-]$$

$$x^2 = (0.492 - x)3.24 \times 10^{-4}$$

$$x^2 + 3.24 \times 10^{-4}x - 1.5941 \times 10^{-4} = 0$$

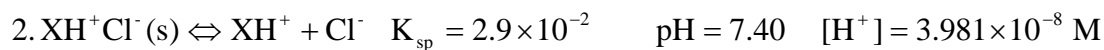
solve using quadratic equation : $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$$x = \frac{-3.24 \times 10^{-4} \pm \sqrt{(3.24 \times 10^{-4})^2 - 4(-1.5941 \times 10^{-4})}}{2}$$

$$x = 1.246 \times 10^{-2} = [H^+]$$

$$pH = -\log(1.246 \times 10^{-2}) = 1.904$$

b) $\alpha = \frac{x}{F} = \frac{1.246 \times 10^{-2}}{0.492} = 0.0253$ or 2.53% is in [A⁻] form, the rest (100 - 2.53) = 97.47% is in [HA] form.



Mass Balance : $[XH^+] + [X] = [Cl^-]$

Charge Balance : $[Cl^-] + [OH^-] = [H^+] + [XH^+]$

$$8.3 \times 10^{-5} = \frac{[H^+][X]}{[XH^+]} = \frac{(3.981 \times 10^{-8})[X]}{[XH^+]} \Rightarrow 8.3 \times 10^{-5} [XH^+] = 3.981 \times 10^{-8} [X]$$

$$K_{sp} = [XH^+][Cl^-] = 2.9 \times 10^{-2}$$

from K_{sp} : $[Cl^-] = \frac{2.9 \times 10^{-2}}{[XH^+]}$

put into mass balance : $[XH^+] + [X] = \frac{2.9 \times 10^{-2}}{[XH^+]} \Rightarrow [XH^+]^2 + [XH^+][X] = 2.9 \times 10^{-2}$

from K_a : $8.3 \times 10^{-5} [XH^+] = 3.981 \times 10^{-8} [X] \Rightarrow 2084.90 [XH^+] = [X]$

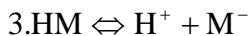
plug into $[XH^+]^2 + [XH^+][X] = 2.9 \times 10^{-2}$

$$[\text{XH}^+]^2 + [\text{XH}^+](2084.90[\text{XH}^+]) = 2.9 \times 10^{-2}$$

$$2085.90[\text{XH}^+]^2 = 2.9 \times 10^{-2}$$

$$[\text{XH}^+] = 3.729 \times 10^{-3} \text{ M}$$

$$\text{solve for } \text{Cl}^- : [\text{Cl}^-] = 7.7776 = 7.8 \text{ M}$$



$$\text{pH} = 2.985 \quad [\text{H}^+] = 1.035 \times 10^{-3} = [\text{M}^-]$$

$$[\text{HM}]_{\text{final}} = 4.50 \times 10^{-2} - 1.035 \times 10^{-3} = 4.396 \times 10^{-2}$$

$$K_a = \frac{[\text{H}^+][\text{M}^-]}{[\text{HM}]} = \frac{(1.035 \times 10^{-3})^2}{4.396 \times 10^{-2}} = 2.4365 \times 10^{-5}$$

$$\text{p}K_a = -\log(K_a) = 4.613$$



$$K_b = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B}]} \Rightarrow 4.50 \times 10^{-5} = \frac{x^2}{0.48 - x}$$

$$2.16 \times 10^{-5} - 4.50 \times 10^{-5} x = x^2$$

$$x^2 + 4.50 \times 10^{-5} x - 2.16 \times 10^{-5} = 0$$

$$\text{plug into quadratic formula : } x = \frac{-4.50 \times 10^{-5} \pm \sqrt{(4.50 \times 10^{-5})^2 - 4(-2.16 \times 10^{-5})}}{2} = 4.625 \times 10^{-3} = [\text{OH}^-]$$

$$[\text{OH}^-] = 4.6 \times 10^{-3} \text{ M}$$

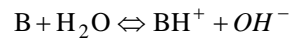
$$\text{pOH} = 2.33$$

$$\text{pH} = 11.665 \approx 11.67$$

$$5. \text{ a) Ephedrine } K_b = 2.30 \times 10^{-5} \quad K_a = \frac{K_w}{K_b} = \frac{1.00 \times 10^{-14}}{2.30 \times 10^{-5}} = 4.35 \times 10^{-10}$$

$$\text{b) Lidocaine } K_a = 1.38 \times 10^{-8}$$

Lidocaine has the larger K_a and is therefore the stronger acid.



$$K_b = \frac{[BH^+][OH^-]}{[B]} \Rightarrow 6.3 \times 10^{-5} = \frac{x^2}{0.060 - x}$$

6. plug into quadratic formula : $x = 1.9_1 \times 10^{-3} = [OH^-]$

$$[OH^-] = 1.9_1 \times 10^{-3} M$$

$$pH = 11.28$$

$$[BH^+] = x = 1.9_1 \times 10^{-3} M$$

$$[B] = F - x = 0.058 M$$