Recitation Section Problems
February 12, 2018
Solutions

1. The pK_a of hydrocyanic acid, HCN, is 9.21. Calculate the pH of an aqueous 0.123 M NaCN solution.

Answer:

$$K_a = 10^{-9.21} = 6.2 \times 10^{-10}$$

$$\mathrm{CN^-_{(aq)}} + \mathrm{H_2O_{(\ell)}} \rightleftharpoons \mathrm{HCN_{(aq)}} + \mathrm{OH^-_{(aq)}}$$

$$K_b = \frac{[\mathrm{HCN}][\mathrm{OH^-}]}{[\mathrm{CN^-}]} = \frac{1.0 \times 10^{-14}}{6.2 \times 10^{-10}} = 1.6 \times 10^{-5}$$

	[CN^-]	[HCN]	[OH^-]
initial	0.123 M	0 M	0 M
change	-y	y	y
equilibrium	(0.123 -y) M	y M	y M

$$\frac{y^2}{0.123 - y} \approx \frac{y^2}{0.123} = 1.6 \times 10^{-5}$$

$$y = [\mathrm{OH^-}] = 1.4 \times 10^{-3}\ \mathrm{M}$$

$$\mathrm{pOH} = -\log_{10}(1.4 \times 10^{-3}) = 2.85 \qquad \mathrm{pH} = 14.00 - 2.85 = 11.15$$

2. The pH of a 2.500 M aqueous hydroxylammonium chloride solution ($HONH_3Cl$) is 2.78. Calculate K_b for the reaction

$$HONH_{2(aq)} + H_2O_{(\ell)} \rightleftharpoons HONH^+_{3(aq)} + OH^-_{(aq)}.$$

Answer:

$$HONH^+_{3(aq)} + H_2O_{(\ell)} \rightleftharpoons HONH_{2(aq)} + H_3O^+_{(aq)}$$

$$[H_3O^+] = 10^{-2.78} = 1.7 \times 10^{-3}\ \text{M} = [HONH_2]$$

$$[HONH^+_3] = 2.500\ \text{M} - 1.7 \times 10^{-3}\ \text{M} = 2.498\ \text{M}$$

$$K_a = \frac{[H_3O^+][HONH_2]}{[HONH^+_3]} = \frac{(1.7 \times 10^{-3})^2}{2.498} = 1.2 \times 10^{-6}$$

$$K_b = \frac{1.0 \times 10^{-14}}{1.2 \times 10^{-6}} = 8.6 \times 10^{-9}$$

3. The pK_a of chlorous acid ($HClO_2$) is 1.96. A solution is made that is 1.20 M in chlorous acid and 0.50 M in sodium chlorite ($NaClO_2$). Calculate the pH of the resulting solution. You must solve the full quadratic equation for this system.

Answer:

$$HClO_{2(aq)} + H_2O_{(\ell)} \rightleftharpoons H_3O^+_{(aq)} + ClO^-_{2(aq)}$$

$$K_a = \frac{[ClO_2^-][H_3O^+]}{[HClO_2]} = 10^{-1.96} = 1.1 \times 10^{-2}$$

	$[HClO_2]$	$[ClO_2^-]$	$[H_3O^+]$
initial	1.20 M	0.50 M	0 M
change	-y	y	y
equilibrium	(1.20 -y) M	(0.50 + y) M	y M

$$\frac{y(y + 0.50)}{1.20 - y} = 1.1 \times 10^{-2}$$

$$y^2 + 0.51y - 0.013 = 0$$

$$y = \frac{-0.51 \pm [(0.51)^2 + 4(0.013)]^{1/2}}{2} = 2.5 \times 10^{-2} \qquad \text{negative solution ignored}$$

$$[H_3O^+] = 2.5 \times 10^{-2} \text{ M} \qquad \text{pH} = -\log_{10}(2.5 \times 10^{-2}) = 1.61$$