Conference Problems – Week of 3/31/08

1. Calculate each of the following, assuming a temperature of 298 K.

a. pH of a solution of 0.01 M HI.

b. The concentration of hydroxide ion at pH 10.

c. The pK_b of an base, whose conjugate acid has a K_a of 1.0×10^{-5}.

2. What is the pH of neutral water at 100˚C, where K_w is 5.1×10^{-13} M^2.

3. What is the pH of a 0.10 M solution of a weak base with a pK_b of 7.0?

4. Glycine is a diprotic acid that has two pK_a values:

$$H_2Gly^+ \xrightarrow{pK_{a1} = 2.4} HGly \xrightarrow{pK_{a2} = 9.8} Gly$$

What is the pH of a solution of 0.10 M HGly?

5. Use the acid dissociation equilibrium expressions to calculate equilibrium constants for the reaction between HOAc (pK_a 4.7) and CN^- (pK_a of HCN is 9.2).

6. A 2.5 g sample of soil is exchanged with sodium acetate, and then the sodium is eluted by the addition of ammonium acetate and is diluted to 50.00 mL. Flame photometry is used to determine that the concentration of sodium in the solution at 0.90 ppm (1 ppm = 1 mg/L). What is the CEC of the soil in meq/100 g soil?

Conference Solutions – Week of 3/31/08

1. Calculate each of the following, assuming a temperature of 298 K.

a. pH of a solution of 0.01 M HNO_3. **pH = 2**
b. The concentration of hydroxide ion at pH 10. **$[OH^-] = 1 \times 10^{-4}$ M**
c. The pK_b of an base, whose conjugate acid has a K_a of 1.0×10^{-5}. **$pK_b = 9$**

2. At 100˚C

$K_w = [H_3O^+][OH^-] = 5.13 \times 10^{-13}\ M^2$

In neutral solution, $[H_3O^+]=[OH^-] = x$

$x^2 = 5.13 \times 10^{-13}\ M^2$
$x = 7.2 \times 10^{-7} M$
$pH = -\log_{10}[H_3O^+] = -\log_{10}(7.2 \times 10^{-7}) =$ **6.14**

3. A base with a pK_b of 7.0 has a $K_b = 1.0 \times 10^{-7}$

$B + H_2O \Leftrightarrow HB^+ + OH^-$

$K_b = [HB^+][OH^-]/[B]$

	[B] (M)	$[HB^+]$ (M)	$[HO^-]$ (M)
I	0.10	0	0
C	-x	x	x
E	0.10 –x	x	x

$K_b = x \cdot x/(0.10-x) \approx x^2/(0.10) = 1.0 \times 10^{-7}$

$[OH^-] = x = 1.0 \times 10^{-4}$ M
$pOH = -\log_{10}[OH^-] = 4$
pH = 14-pOH = 10

4. What is the pH of a solution of 0.10 M HGly?

The pK_b of Gly = $14-pK_{a1} = 11.6$
The pK_a of Gly = $pK_{a2} = 9.8$. Thus Gly is a stronger acid than base.

$HGly + H_2O \Leftrightarrow Gly^- + H_3O^+$

	[HGly] (M)	[Gly] (M)	$[H_3O^+]$ (M)
I	0.10	0	0
C	-x	x	x
E	0.10 –x	x	x

$K_a = x \cdot x/(0.10-x) \approx x^2/(0.10) = 10^{-9.8}$
$x = 4.0 \times 10^{-6}$ M
$pH = -\log_{10}(4.0 \times 10^{-6}) = 5.4$

5. Use the acid dissociation equilibrium expressions to calculate equilibrium constants for the following reaction:

HOAc (pK_a 4.7) and CN^- (pK_a of HCN is 9.2)

$$NH_4^+ + F^- \Leftrightarrow NH_3 + HF$$

$$K_{eq} = \frac{[HCN][OAc^-]}{[CN^-][HOAc]} = \frac{[HCN]}{[CN^-][H_3O^+]} \cdot \frac{[H_3O^+][OAc^-]}{[HOAc]} = \frac{1}{10^{-9.2}} \cdot 10^{4.7} = 10^{13.9}$$

6. A 2.5 g sample of soil is exchanged with sodium acetate, and then the sodium is eluted by the addition of ammonium acetate and is diluted to 50.00 mL. Flame photometry is used to determine that the concentration of sodium in the solution at 0.90 ppm (1 ppm = 1 mg/L). What is the CEC of the soil in meq/100 g soil?

(0.90 ppm)(1 mg/L)(1 g/1000 mg)(1 mol/23 g)(50 mL)(1 L/1000 mL) = 1.9×10^{-6} mol

(1.9×10^{-6} mol)(1000 meq/mol)(100 g/2.5 g) = 0.078 meq/100 g