Chemistry 1212 Name____KEY____
March 30, 2012
Exam #3

Write very clearly and **show all of your work** for partial credit. A list of equations and constants as well as a periodic table are on the last two pages of your exam.

1.(15 points) Fill in the space with the correct response.

(a) The –log(K_b) is called the $\boxed{pK_b}$

(b) Give an example of a Lewis base $\boxed{OH^-, NH_3, lp\ donor}$

(c) An Arrhenius base is a/an $\boxed{\text{hydroxide}}$ donor.

(d) Identify the strongest acid in the following sets.

(i) $H_3PO_4, H_2PO_4^-, HPO_4^{2-}$ $\boxed{H_3PO_4}$

(ii) H_3PO_4, HNO_3, HF $\boxed{HNO_3}$

(iii) $HOI, HOF, HOCl, HOBr$ $\boxed{HOF}$

(e) Identify the strongest base in the following sets.

(i) $H_3PO_4, H_2PO_4^-, HPO_4^{2-}$ $\boxed{HPO_4^{2-}}$

(ii) F^-, Br^-, Cl^-, I^- $\boxed{F^-}$

(iii) $NH_3, CH_3NH_2, (CH_3)_2NH_2$ $\boxed{(CH_3)_2NH_2}$

(f) State whether the pH is basic, acidic, or neutral for each of the salts below.

(i) NH_4HSO_4 $\boxed{acidic}$

(ii) KF $\boxed{basic}$

(iii) LiI $\boxed{neutral}$

2. (18 points) The pH of a 0.050 M solution of $C_2H_5NH_2$ is 11.73. Write the balanced net ionic equation. Is this an acid or a base? What is the value of the dissociation constant?

	$C_2H_5NH_2$	H_2O	$\rightleftharpoons$	$C_2H_5NH_3^+$ $(3pts)$	OH^-
I	0.050	-		0	0
C	-x	-		+x	+x
E	0.050 - x	-		+x	+x

(1pt for table)

It's a base. (1 pt)

$$\left[H^+\right]=10^{-11.73}=1.862\times10^{-12}M \quad (3pts)$$

$$\left[OH^-\right]=\frac{10^{-14}}{1.862\times10^{-12}}=5.370\times10^{-3}M \quad (3pts)$$

$$K_b=\frac{\left[OH^-\right]\left[C_2H_5NH_3^+\right]}{\left[C_2H_5NH_2\right]} \quad (2pts)$$

$$K_b=\frac{x^2}{0.050-x} \quad (2pts)$$

$$K_b=\frac{\left(5.370\times10^{-3}\right)^2}{0.050-0.005370}=6.46\times10^{-4} \quad (3pts)$$

3. (7 points) How many mL of a 0.56 M solution of $Ba(OH)_2$ are needed to neutralize 500 mL of a 0.25 M HNO_3 solution?

$$Ba\left(OH\right)_2+2HNO_3\rightarrow Ba\left(NO_3\right)_2+2H_2O \quad (1pt)$$

$$500\,mL\times\frac{1\,L}{1000\,mL}\times\frac{0.25\,moles\ HNO_3}{1\,L}\times\frac{1\,mol\ H^+}{1\,mol\ HNO_3}=0.125\,mol\ H^+ \quad (2pts)$$

$$\frac{L}{0.56\,moles\ Ba\left(OH\right)_2}\times\frac{1\,mol\ Ba\left(OH\right)_2}{2\ mol\ OH^-}\times\frac{1\,mol\ OH^-}{1\,mol\ H^+}\times0.125\,mol\ H^+=0.112\,L \quad (2pts)$$

$$112\,mL \quad (2pts)$$

4. (30 points) Determine the pH for each of the following.

a.) 0.500 <u>M</u> HN_3 with $K_a = 1.9 \times 10^{-5}$

	HN_3	$\rightleftharpoons$	H^+	N_3^-
I	0.500		0	0
C	-x		+x	+x
E	0.500 - x		+x	+x

(1pt for table)

$$K_a = \frac{[H^+][N_3^-]}{[HN_3]} \quad (2\,pts)$$

$$1.9\times10^{-5} = \frac{x^2}{0.500-x} \quad (1\,pt)$$

$$assume\ x \ll 0.500 \quad 1.9\times10^{-5} \sim \frac{x^2}{0.500} \rightarrow x = 3.08\times10^{-3}M \quad (2\,pts)$$

$$ck: \quad \frac{3.08\times10^{-3}}{0.500}\times100 = 0.6\% < 5\% \therefore valid \quad (1\,pt)$$

$$pH = -\log[H^+] = 2.51 \quad (3\,pts)$$

b.) 0.250 M NaN_3

$$NaN_3 \rightarrow \underset{0.250}{Na^+} + \underset{0.250}{N_3^-}$$

	N_3^-	H_2O	$\rightleftharpoons$	HN_3	OH^-
I	0.250	-		0	0
C	-x	-		+x	+x
E	0.250 - x	-		+x	+x

(1 pt for table)

$$K_b = \frac{[HN_3][OH^-]}{[N_3^-]} \quad (2\,pts)$$

$$\frac{10^{-14}}{1.9\times10^{-5}} = 5.26\times10^{-10} = \frac{x^2}{0.250-x} \quad (1\,pt)$$

$$assume\ x \ll 0.250 \quad 5.26\times10^{-10} \sim \frac{x^2}{0.250} \rightarrow x = 1.147\times10^{-5}M \quad (2\,pts)$$

$$ck: \quad \frac{1.147\times10^{-5}}{0.250}\times100 = 0.005\% < 5\% \therefore valid \quad (1\,pt)$$

$$pH = 14 - pOH = 9.06 \quad (3\,pts)$$

c.) 0.300 L solution containing 0.400 M HN_3 and 0.100 M NaN_3

$$pH = pK_a + \log\left(\frac{[N_3^-]}{[HN_3]}\right) \quad (5\,pts)$$

$$pH = 4.12 \quad (5\,pts)$$

5. (30 points) Determine the molar solubility for each of the following.

a.) $Ca_3(PO_4)_2$ given $K_{sp} = 2.0 \times 10^{-29}$

$$Ca_3(PO_4)_2 \rightleftharpoons 3Ca^{2+} + 2PO_4^{3-}$$

3s 2s (2pts)

$$K_{sp} = \left[Ca^{2+}\right]^3 \left[PO_4^{3-}\right]^2 \quad (2\,pts)$$

$$2.0\times10^{-29} = (3s)^3 (2s)^2 = 108s^5 \quad (2\,pts)$$

$$s = 7.14\times10^{-7} M \quad (2\,pts)$$

$$\left[Ca^{2+}\right] = 3s = 2.1\times10^{-6} M \quad (1\,pt)$$

$$\left[PO_4^{3-}\right] = 2s = 1.4\times10^{-6} M \quad (1\,pt)$$

b.) $Ca_3(PO_4)_2$ in a solution containing 0.010 M $Ca(OH)_2$

	$Ca_3(PO_4)_2$	$\rightleftharpoons$	$3\,Ca^{2+}$	$2\,PO_4^{3-}$
I			0.010	0
C			+3s	+2s
E			0.010+3s	+2s

(1pt for table)

$$2.0\times10^{-29} = (0.010+3s)^3 (2s)^2 \quad (2\,pts)$$

$$assume\ 3s \ll 0.010 \quad (1\,pt)$$

$$2.0\times10^{-29} \sim (0.010)^3 (2s)^2 \rightarrow s = 2.23\times10^{-12} M \quad (2\,pts)$$

$$ck: \frac{3\times2.23\times10^{-12}}{0.010}\times100\% = 7\times10^{-8}\% < 5\% \quad (2\,pts)$$

$$\left[Ca^{2+}\right] = 0.010 + 3s = 0.010M \quad (1\,pt)$$

$$\left[PO_4^{3-}\right] = 2s = 4.46\times10^{-12} M \quad (1\,pt)$$

c.) $Ca_3(PO_4)_2$ in a solution containing 0.010 M of K_2PO_4

	$Ca_3(PO_4)_2$	$\rightleftharpoons$	$3\,Ca^{2+}$	$2\,PO_4^{3-}$
I			0	0.010
C			+3s	+2s
E			+3s	0.010+2s

(1pt for table)

$$2.0\times10^{-29} = (3s)^3 (0.010+2s)^2 \quad (2\,pts)$$

$$assume\ 2s \ll 0.010 \quad (1\,pt)$$

$$2.0\times10^{-29} \sim (3s)^3 (0.010)^2 \rightarrow s = 1.95\times10^{-9} M \quad (2\,pts)$$

$$ck: \frac{2\times1.95\times10^{-9}}{0.010}\times100\% = 4\times10^{-5}\% < 5\% \quad (2\,pts)$$

$$\left[Ca^{2+}\right] = 3s = 5.8\times10^{-9} M \quad (1\,pt)$$

$$\left[PO_4^{3-}\right] = 0.010 + 2s = 0.010M \quad (1\,pt)$$