

Chemistry 1212
March 30, 2012
Exam #3

Name KEY

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

pK_b

(b) Give an example of a Lewis base

OH^- , NH_3 , *lp donor*

(c) An Arrhenius base is a/an hydroxide donor.

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

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

H_3PO_4

(ii) H_3PO_4 , HNO_3 , HF

HNO_3

(iii) HOI , $HOCl$, $HOBr$

HOI

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

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

HPO_4^{2-}

(ii) F^- , Br^- , Cl^- , I^-

F^-

(iii) NH_3 , CH_3NH_2 , $(CH_3)_2NH_2$

$(CH_3)_2NH_2$

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

(i) NH_4HSO_4

acidic

(ii) KF

basic

(iii) LiI

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	$C_2H_5NH_3^+$ (3 pts)	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)

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

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

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

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

$$K_b = \frac{(5.370 \times 10^{-3})^2}{0.050 - 0.005370} = 6.46 \times 10^{-4} \quad (3pts)$$

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?



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

$$\frac{L}{0.56 \text{ moles } Ba(OH)_2} \times \frac{1 \text{ mol } Ba(OH)_2}{2 \text{ mol } OH^-} \times \frac{1 \text{ mol } OH^-}{1 \text{ mol } H^+} \times 0.125 \text{ mol } H^+ = 0.112 L \quad (2pts)$$

112 mL (2pts)

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

a.) 0.500 M 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)

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

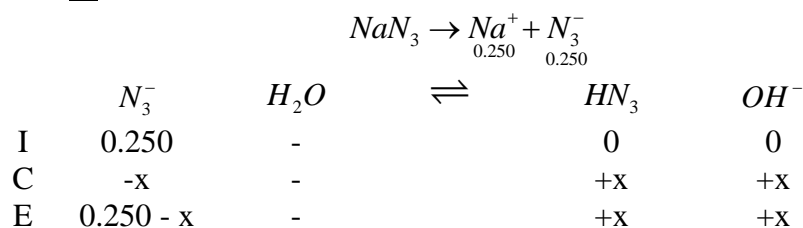
$$1.9 \times 10^{-5} = \frac{x^2}{0.500 - x} \quad (1 \text{ pt})$$

$$\text{assume } x \ll 0.500 \quad 1.9 \times 10^{-5} \sim \frac{x^2}{0.500} \rightarrow x = 3.08 \times 10^{-3} \text{ M} \quad (2 \text{ pts})$$

$$\text{ck: } \frac{3.08 \times 10^{-3}}{0.500} \times 100 = 0.6\% < 5\% \therefore \text{valid} \quad (1 \text{ pt})$$

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

b.) 0.250 M NaN_3



(1 pt for table)

$$K_b = \frac{[\text{HN}_3][\text{OH}^-]}{[\text{N}_3^-]} \quad (2 \text{ pts})$$

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

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

$$\text{ck: } \frac{1.147 \times 10^{-5}}{0.250} \times 100 = 0.005\% < 5\% \therefore \text{valid} \quad (1 \text{ pt})$$

$$\text{pH} = 14 - \text{pOH} = 9.06 \quad (3 \text{ pts})$$

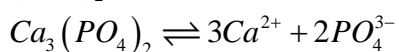
c.) 0.300 L solution containing 0.400 M HN_3 and 0.100 M NaN_3

$$\text{pH} = \text{p}K_a + \log\left(\frac{[\text{N}_3^-]}{[\text{HN}_3]}\right) \quad (5 \text{ pts})$$

$$\text{pH} = 4.12 \quad (5 \text{ pts})$$

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

a.) $\text{Ca}_3(\text{PO}_4)_2$ given $K_{\text{sp}} = 2.0 \times 10^{-29}$



3s 2s (2pts)

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

$$2.0 \times 10^{-29} = (3s)^3 (2s)^2 = 108s^5 \quad (2pts)$$

$$s = 7.14 \times 10^{-7} M \quad (2pts)$$

$$[Ca^{2+}] = 3s = 2.1 \times 10^{-6} M \quad (1pt)$$

$$[PO_4^{3-}] = 2s = 1.4 \times 10^{-6} M \quad (1pt)$$

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

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

(1pt for table)

$$2.0 \times 10^{-29} = (0.010 + 3s)^3 (2s)^2 \quad (2pts)$$

$$\text{assume } 3s \ll 0.010 \quad (1pt)$$

$$2.0 \times 10^{-29} \sim (0.010)^3 (2s)^2 \rightarrow s = 2.23 \times 10^{-12} M \quad (2pts)$$

$$ck: \frac{3 \times 2.23 \times 10^{-12}}{0.010} \times 100\% = 7 \times 10^{-8}\% < 5\% \quad (2pts)$$

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

$$[PO_4^{3-}] = 2s = 4.46 \times 10^{-12} M \quad (1pt)$$

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

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

(1pt for table)

$$2.0 \times 10^{-29} = (3s)^3 (0.010 + 2s)^2 \quad (2pts)$$

$$\text{assume } 2s \ll 0.010 \quad (1pt)$$

$$2.0 \times 10^{-29} \sim (3s)^3 (0.010)^2 \rightarrow s = 1.95 \times 10^{-9} M \quad (2pts)$$

$$ck: \frac{2 \times 1.95 \times 10^{-9}}{0.010} \times 100\% = 4 \times 10^{-5}\% < 5\% \quad (2pts)$$

$$[Ca^{2+}] = 3s = 5.8 \times 10^{-9} M \quad (1pt)$$

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