CHEM 1202 - Homework # 7 & 8 **ANSWER KEY**

Acids & Bases # 2 ***Due Tuesday, Nov 16th, 1999***

Table 1. Dissociation Constants for some Acids.

Acid	pK_a Value	Acid	pK_a Value	Acid	pK_a Value
CH_4	24	H_2S	7.0	H_3PO_4	2.1
CF_3COOH	–2	Benzoic	4.2	HPF_6	–10

1. (5 pts) Circle the following acid that will have a pH closest to **7** for a 0.1 M aqueous solution?

   a) CF_3COOH b) benzoic c) H_3PO_4 d) CH_4 e) HPF_6

   The acid that will have its pH closest to 7 will be the *weakest* acid. This will be the one with the largest pK_a value. The strongest acid will have the most acidic pH, which for a 0.1 M solution would be pH = 1.

2. (5 pts) Circle the following acid that when reacted with an equivalent amount of NaOH will form a solution with a pH closest to 7?

   a) H_2S b) benzoic c) H_3PO_4 d) CH_4 e) HPF_6

   For this problem we are looking for the strongest acid. Strong acids react with strong bases (like NaOH) to produce neutral salts (do-nothing cations and do-nothing anions). The strongest acid is HPF_6, with a pK_a = –10.

3. (5 pts) Order the acids in Table 1 from ***strongest*** to *weakest*. Circle the correct choice.

   a) $CH_4 > H_2S >$ benzoic $> H_3PO_4 > CF_3COOH > HPF_6$

   b) $HPF_6 > CF_3COOH > H_3PO_4 >$ benzoic $> H_2S > CH_4$

   c) benzoic $> H_2S > H_3PO_4 > HPF_6 > CF_3COOH > CH_4$

   d) $H_2S >$ benzoic $> H_3PO_4 > CF_3COOH > HPF_6 > CH_4$

   e) $H_3PO_4 > H_2S > HPF_6 >$ benzoic $> CF_3COOH > CH_4$

   The strongest acid is the one with the most negative pK_a value, which in in this case is HPF_6, with a pK_a = –10. One then sorts the list from smallest pK_a to the largest (weakest acid).

4. (5 pts) What is the pH of a 1 M solution of the base methylamine (CH_3NH_2)? pK_a = 10. Please show all your work.

	Base(*aq*)	+ $H_2O(l)$	⇌	$BaseH^+(aq)$	+ $OH^-(aq)$
Initial:	1M	pure liq		0M	0M
@ Equib:	1 – x	pure liq		x	x

You first need to convert the pK_a into a K_a, then into a K_b for this *basic* equilibrium:

$$K_b = \frac{K_W}{K_a} = \frac{1\times10^{-14}}{1\times10^{-10}} = 1\times10^{-4}$$ now you can setup your equilib: $$K_b = \frac{(x)(x)}{(1-x)} = 1\times10^{-4}$$

assume that x << 1, $\frac{(x)(x)}{(1)} = 1\times10^{-4}$ or $x^2 = 1 \times 10^{-4}$, or $x = [OH^-] = 1 \times 10^{-2}$ pOH = 2. ***BUT THIS IS NOT YOUR ANSWER***, since I asked for the pH!! **pH = 14 – 2 = 12**

a) 4 b) 5 c) 8 d) 12 e) 22

5. (5 pts) Circle the following pK_a value that best fits the extremely strong base KH (potassium hydride)?

   a) –20 b) 0 c) 7 d) 14 e) 30

6. (10 pts) What is the pH of a 0.01 M solution of KCN? $pK_a = 4$. Clearly show all your work.

The first thing to realize is that this is a **basic salt** that will generate a ***basic*** solution! K^+ is a do-nothing cation, while CN^- is a ***basic*** anion that acts as a weak base in solution.

Initial:	**0.01 M**	**pure liq**		**0M**	**0M**
	$Base^-(aq)$ + $H_2O(l)$	⇌		**$BaseH(aq)$ + $OH^-(aq)$**	
@ Equib:	**0.01 – x**	**pure liq**		**x**	**x**

Next you need to convert the pK_a value I've given you into a K_a, then K_b for the conjugate base in this basic equilibrium:

$K_b = \frac{K_W}{K_a} = \frac{1\times10^{-14}}{1\times10^{-4}} = 1\times10^{-10}$ now you can setup your equilib: $K_b = \frac{(x)(x)}{(0.01-x)} = 1\times10^{-10}$

assume that x << 0.01, $\frac{(x)(x)}{(0.01)} = 1\times10^{-10}$ or $x^2 = 1 \times 10^{-12}$, or $x = [OH^-] = 1 \times 10^{-6}$

pOH = 6. ***BUT THIS IS NOT YOUR ANSWER***, since I asked for the pH!! pH = 14 – pOH = 8 so the **pH = 8**

7. (10 pts) Consider the following list of salts (use information from your notes & Table 1 to help):

A) Li_2CO_3 B) $Al_2(SO_4)_3$ C) Na_2S D) NH_4Cl

E) $Ca(OH)_2$ F) BeI_2 G) potassium acetate H) $LiNO_3$

I) CsBr J) $Co(PF_6)_3$

Which salts will generate an ***acidic*** solution? **B, D, F, J**

Which salts will generate a ***basic*** solution? **A, C, E, G**

Which salts will generate a ***neutral*** solution? **H, I**

8. (10 pts) What is the pH if 500 mL of 0.2 M HCl is added to 500 mL of 0.2 M ammonia (NH_3) $pK_a = 9$

The first thing to realize is that ammonia is a weak base and that we are titrating it with a strong acid. If there are equal amounts of each, we will be making the salt of a weak base, which is a weak acid! Calculate the # of moles of each:

moles strong acid = (500 mL HCl)(0.2 M HCl) = 100 mmoles H+
moles weak base = (500 mL ammonia)(0.2 M ammonia) = 100 mmoles ammonia

Don't forget that we will make 1000 mL total solution volume. This will generate a 100 mmoles/1000 mL = 0.1 M solution of NH_4Cl, which is a ***weak acid***.

Write out an acid equilibria, convert the pK_a into K_a and calculate [H+]:

Initial:	**0.1 M**		**0M**	**0M**	
	$NH_4^+(aq)$	⇌	**$H^+(aq)$ + $NH_3(aq)$**		**$K_a = 1 \times 10^{-9}$**
@ Equib:	**0.1 – x**		**x**	**x**	

now you can setup your equilib: $K_a = \frac{(x)(x)}{(0.1-x)} = 1\times10^{-9}$ assume that x << 0.1: $\frac{(x)(x)}{(0.1)} = 1\times10^{-9}$

or $x^2 = 1 \times 10^{-10}$, or $x = [H^+] = 1 \times 10^{-5}$ so the **pH = 5**

9. (5 pts) Calculate the pK_b of the weak base phenylamine if a 1 M solution has a pH = 10.

A pH of 10 means that the pOH is 4. We do NOT use the pH directly in this problem because we are dealing with a basic equilibrium!! Thus, we know that the $[OH^-] = 1 \times 10^{-4}$ M.

Initial:	**1 M**	**pure liq**		**0M**	**0M**
	$Base^-(aq)$ + $H_2O(l)$	⇌		**$BaseH(aq)$ + $OH^-(aq)$**	
@ Equib:	**1 – x**	**pure liq**		**x**	**x**
@ Equib:	**$1 - 1 \times 10^{-4}$**			**1×10^{-4}**	**1×10^{-4}**

Plug into the K_b expression and solve: $K_b = \frac{(1\times10^{-4})^2}{1-1\times10^{-4}} = 1\times10^{-8}$ **$pK_b = 8$**