This is ACA # 25. It is OK to use your textbook, but if you can answers the questions without it that is OK too.

I recommend you print out this page and bring it to class. Click here to show a set of five ACA25 student responses, randomly selected from all of the student responses thus far, in a new window.

John , here are your responses to the ACA and the Expert's response.

1. Determine K for each of the following reactions;

a) $C_2H_3O_2^- + H_2O \rightarrow HC_2H_3O_2 + OH^-$

K = 5.5e-10 56%

In the equation $C_2H_3O_2^-$ is behaving as a base. $C_2H_3O_2^-$ is the conjugate base of the weak acid $HC_2H_3O_2$. To determine the K for the reaction we must separate the equation into two equations whose K we know. The two equations are,

$C_2H_3O_2^- + H^+ \rightarrow HC_2H_3O_2$ ($1/K_a(HC_2H_3O_2)$)

$H_2O \rightarrow H^+ + OH^-$ (K_w)

$C_2H_3O_2^- + H_2O \rightleftarrows HC_2H_3O_2 + OH^-$ $K = K_w/K_a = 1.0 \times 10^{-14}/1.8 \times 10^{-5}$

$K_b = 5.6 \times 10^{-10}$.

b) $NH_3 + H^+ \rightarrow NH_4^+$

22% $K_b(NH_3)$

K = 1.8e9 17%

This reaction is a neutralization reaction because it involves a weak base (NH_3) reacting with a strong acid (H^+). For this type of neutralization reaction two reactions are needed to determine K. The two equations are,

$NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$ ($K_b(NH_3)$)

$H^+ + OH^- \rightarrow H_2O$ ($1/K_w$)

$NH_3 + H^+ \rightarrow NH_4^+$ $K = K_b/K_w = 1.8 \times 10^{-5}/1.0 \times 10^{-14}$

$K = 1.8 \times 10^9$

This value is a very large number. That is what we expect for any neutralization reaction.

2. Consider the solution below and indicate which of the following is the best classification;

Classification

Weak Acid
Weak base
Strong Acid
Strong base
Salt (SA/SB)
Salt (SA/WB)
Salt (WA/SB)
Common Ion
Buffer
Neutralization

a) 0.500 M HClO

weak acid 89%

HClO is not the formula for a strong acid, so it must be a weak acid.

b) 0.500 M $(C_2H_5)_3N$ 83%

weak base

$(C_2H_5)_3N$ is a weak base. The nitrogen atom has a lone pair and can accept a proton (H^+). The C_2H_5 group is the same as CH_3CH_2 group which we learned about in the Survival Organic laboratory and cannot accept a proton (H^+).

c) 0.500 M NH_4ClO_4

salt (SA/WB) 67%

NH_4ClO_4 is a salt of a weak base (NH_3) and a strong acid ($HClO_4$) and will behave as a weak acid in solution.

d) 0.500 M Na_2CO_3 and 0.500 M $NaHCO_3$

common ion (WB/CA) 61%

This mixture is a buffer/common ion. $NaHCO_3$ is a salt of a strong base (NaOH) and a weak acid (H_2CO_3) so Na^+ will not affect the pH of the solution so it can be neglected leaving HCO_3^-. Na_2CO_3 is a salt of a strong base (NaOH) and a weak acid (HCO_3^-) and Na^+ will not affect the pH of the solution so it can be neglected leaving CO_3^{2-}. HCO_3^- and CO_3^{2-} differ by a proton so are a weak acid and its conjugate base. This meets the definition of a buffer solution/common ion solution.

e) 0.500 M $HC_3H_5O_2$ and 0.500 M KOH

neutralization 44%

When $HC_3H_5O_2$ and KOH are mixed a neutralization reaction will occur. This is a mixture of a weak acid and a strong base that are unrelated.

3. Given 500. mLs of a solution that is 0.100 M NH_3 and 0.100 M NH_4NO_3?

a) Write the balanced chemical equation that can be used to calculate the pH of this solution.

NH3(aq) + H2O(l) --> NH4^+(aq) + OH^-(aq) 39%

NH_3 is a weak base and NH_4NO_3 is a salt of a weak base and a strong acid. So NO_3^- is the conjugate base of the strong acid HNO_3 and does not affect the pH of the solution so it can be neglected. After removing the NO_3^- ion the solution is a mixture of NH_3 and NH_4^+. This is a weak base and its conjugate acid, also known as a buffer solution.

The reaction is $NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

This reaction works because it contains both the weak base (NH_3) and the conjugate acid (NH_4^+) and OH^- which allows the determination of the pH.

b) What is the value of K for this reaction?

K = 1.8e-5 33%

Since NH_3 is a weak base we can locate the K_b in the table of weak base equilibrium constants. It has a value of 1.8×10^{-5}.

c) Calculate the pH of the solution. pH = 9.26 33%

	$NH_3(aq)$ +	$H_2O(l)$	$\rightleftarrows$	$NH_4^+(aq)$ +	$OH^-(aq)$
I	0.100	-		0.100	~0
C	-x	-		+x	+x
E	0.100 - x	-		0.100 + x	+x

$K_a = [NH_4^+][OH^-]/[NH_3]$

$1.8 \times 10^{-5} = [0.100 + x][x]/[0.100 - x]$

assume $0.1 - x = 0.1$

$1.8 \times 10^{-5} = [0.100][x]/[0.100]$

$1.8 \times 10^{-5} = [x] = [OH^-]$

The pOH of the solution is 4.74 and the pH is 14 - pOH which is 9.26. The solution is basic.

d) If 0.0050 moles of NaOH is added to the solution would you expect the pH of the

solution to increase, decrease or remain the same?

increase 6/6

The pH should increase. Adding a strong base to a buffer will cause the amount of the weak acid to decrease and the amount of the conjugate base to increase. This will make the pH more basic.

e) Calculate the new pH of the solution.

pH = 9.34 6/6

The strong base that is added to the solution will be neutralized by the acid component of the buffer. We always do neutralization reactions in terms of moles, so the initial moles of NH_4^+ and NH_3 are,

0.500 L (0.100 mol NH_4^+/1 L) = 0.0500 mol NH_4^+

0.500 L (0.100 mol NH_3/1 L) = 0.0500 mol NH_3

	$NH_4^+(aq)$ +	$OH^-(aq)$	$\rightleftarrows$	$NH_3(aq)$ +	$H_2O(l)$
I	0.0500	0.0050		0.0500	-
C	-0.0050	-0.0050		+0.0050	-
E	0.0450	0		0.0550	-

The solution following the neutralization of the strong base ends up (the E row) as a solution of a weak base and its conjugate acid, which is a buffer. So to calculate the pH we can use the same equation as was used to calculate the initial pH of the solution. Remember when calculating pH the amount of each species must expressed in molarity. Converting the amount of NH_4^+ and NH_3 to mol/L,

0.0450 mol NH_4^+/0.500 L = 0.0900 M NH_4^+

0.0550 mol NH_3/0.500 L = 0.110 M NH_3

	$NH_3(aq)$ +	$H_2O(l)$	$\rightleftarrows$	$NH_4^+(aq)$ +	$OH^-(aq)$
I	0.110	-		0.0900	~0
C	-x	-		+x	+x
E	0.110 - x	-		0.0900 + x	+x

$K_a = [NH_4^+][OH^-]/[NH_3]$

$1.8 \times 10^{-5} = [0.0900 + x][x]/[0.110 - x]$

assume 0.09 - x = 0.09

$1.8 \times 10^{-5} = [0.090][x]/[0.110]$

$2.2 \times 10^{-5} = [x] = [OH^-]$

The pOH of the solution is 4.66 and the pH is 14 - pOH which is 9.34. The change in pH is 0.08.

4. Is there anything about the questions that you feel you do not understand? List your concerns/questions.

nothing

5. If there is one question you would like to have answered in lecture, what would that question be?

nothing