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REFLECTION QUESTIONS

1. When calculating the pH of a buffer system, what quantities do you need to have?
   You need the K_a value for the acidic component of the buffer along with moles or molarity values for the acidic and basic components of the system.

2. Why is it important to be working with moles or millimoles when dealing with an invader in a buffer?
   These problems are actually chemical reactions happening and quantities of change of the acid and base part of the buffer must be calculated in moles.

3. When dealing with a buffer invader problem, what other chemistry problems are these similar to?
   These are similar to limiting reactant problems.

4. Why does the pH of a buffer system not change significantly when invaded by a small quantity of strong acid or base?
   Because the invading strong acid or base is converted by one component of the buffer into the other component of the buffer. Thus, there is not a large change in free H^+ or OH^- ions which are responsible for pH changes.

5. Why is it not necessary to use molarity values when calculating $[H^+]$ for a buffer but molarity values must be used when dealing with a simple weak acid equilibrium expression?
   Buffer calculations have a ratio of acid to base and the volume values used in molarity calculations cancel out in the calculation. In an equilibrium expression, these volumes do not cancel out and molarity must be used.

6. Why does the pH = pKa at the ½ equivalence point in the titration?
   At the ½ equivalence point, there are equivalent moles of acid and base component in the buffer. Therefore the ratio of acid to base is 1 and $[H^+] = K_a$. Therefore, $pH = pK_a$.

7. Look back at problems 2(b) and 2(c). What did you have to do differently in the problems?
   The K_a of the acidic component of the buffer was given directly for 2(b), but only the K_b for the basic component was given in 2(c). Therefore, a K_a value had to be calculated in 2(c) in order to calculate the pH.

8. When creating a buffer, what is the most important factor in the pH of the system?
   The value of the Ka is the most important factor to setting the pH. You want the pK_a to be as close as possible to the desired pH.

9. When creating a buffer, what is the most important factor in the capacity of the system for handling invading acid or base?

   The quantity of acid and base components in the buffer determines the capacity of the system for handling invaders.

AP Chem - Unit 10 - Skill Builder Buffers

* FR 1993 Q1

Base CA

$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$

$K_b = 5.25 \times 10^{-4}$

B) 120.0 mL
.225 M

Add $(CH_3NH_3^+)(NO_3^-)$ 0.0100 mole

Given:

$K_a = \frac{K_w}{K_b} = \frac{1 \times 10^{-14}}{5.25 \times 10^{-4}}$ PH = ?

$K_a = 1.90 \times 10^{-11}$

$[CH_3NH_2] = (120.0 mL)(.225 M) = 27.0 mmol$ BASE

$[(CH_3NH_3^+)NO_3^-] = 0.0100 mol \left(\frac{1000 mmole}{1 mole}\right) = 10.0 mmol$ Acid

$[H^+] = K_a \frac{[Acid]}{[Base]}$

$= (1.90 \times 10^{-11})\left(\frac{10.0}{27.0}\right)$

$[H^+] = 7.00 \times 10^{12}$

$pH = -\log[H^+]$

$\boxed{pH = 11.15}$

C) HCl must be added to Achieve pH = 11.00 (need to lower!)

$pH = 11.00$ $pH = -\log[H^+]$

$[H^+] = 10^{-11} = 1 \times 10^{-11}$

$[H^+] = K_a \frac{Acid}{BASE}$ Add Acid ? mmol HCl = X

$[H^+] = K_a \frac{(Acid + X)}{(BASE - X)}$

$1 \times 10^{-11} = 1.90 \times 10^{-11} \frac{(10.0 + X)}{(27.0 - X)}$

$.526(27.0 - X) = 10.0 + X$

$14.2 - .526X = 10.0 + X$

$1.526X = 4.2$

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FR 1993 Q1 cont.

$\boxed{X = 2.8 \text{ mmol HCl}}$ or $\frac{2.8 \text{ mmol}}{1}\left(\frac{1 \text{ mole}}{1000 \text{ mmol}}\right) = 0.0028 \text{ mole}_{HCl}$

d) Adding H_2O (100. mL) will dilute Both the Acid & Base. The Ratio $\frac{\text{Acid}}{\text{Base}}$ does not change

∴ there is NO effect on pH

AP Problems

1993 Q1

$$CH_3NH_2 + H_2O \leftrightarrow CH_3NH_3^+ + OH^-$$

Methylamine, CH_3NH_2, is a weak base that reacts according to the equation above. The value of the ionization constant, K_b, is 5.25×10^{-4}. Methylamine forms salts such as methylammonium nitrate, $(CH_3NH_3^+)(NO_3^-)$.

(b) Calculate the pH of a solution made by adding 0.0100 mole of a solid methylammonium nitrate to 120.0 milliliters of a 0.225-molar solution of methylamine. Assume that no volume change occurs.

120.0 mL * 0.225 M = 27 mmol CH_3NH_2 or 0.0100 mol / 0.120 L = 0.0833 M $CH_3NH_3^+$ $K_a = \frac{1.0\times10^{-14}}{5.25\times10^{-4}} = 1.90\times10^{-11}$ $[H^+] = 1.90x10^{-11}\left[\frac{10 \text{ mmol } CH_3NH_3^+}{27 \text{ mmol } CH_3NH_2}\right]$ $[H^+] = 7.04\times10^{-12}$ pH = -log(7.04×10^{-12}) = 11.15	1 point for calculating moles of CH_3NH_2 or molarity of $CH_3NH_3^+$ 1 point for substituting molarity or moles values correctly. 1 point for correct pH

(c) How many moles of <u>either</u> NaOH <u>or</u> HCl (state clearly which you choose) should be added to the solution in (b) to produce a solution that has a pH of 11.00? Assume that no change in volume occurs.

HCl must be added. $[H^+] = 10^{-11.0} = 1.0\times10^{-11}$ $1.0\times10^{-11} = 1.90\times10^{-11}\left[\frac{10+x}{27-x}\right]$ $0.526 = \left[\frac{10+x}{27-x}\right]$ $14.21 - 0.526x = 10 + x$ 4.21 = 1.526 x x = 2.75 mmol = 0.00275 moles HCl	1 point for identifying compound to be added (consistent with pH value from (b)). 1 point for correct number of moles.

(d) A volume of 100. milliliters of distilled water is added to the solution in (c). How is the pH of the solution affected? Explain.

The $\left[\frac{CH_3NH_3^+}{CH_3NH_2}\right]$ ratio does not change in this buffer solution with dilution. Therefore, there is no effect on pH.	1 point for correct answer with a valid explanation.