Buffers

Common Ion Effect

Equilibrium of Weak Acids-Bases

- The shift in equilibrium that occurs because of the addition of an ion already involved in the equilibrium reaction.
- $HF_{(aq)} \leftrightarrows H^+_{(aq)} + F^-_{(aq)}$
- Add $F^-_{(aq)}$ What is the effect on pH?

QUESTION

Suppose the weak acid HNO_2 ($K_a = 4.0 \times 10^{-4}$) is added to a solution of $NaNO_2$. If the concentration of acid is 0.10 *M* and the salt concentration is 0.060 *M*, what is the $[H^+]$?

A. 2.4×10^{-4} *M*
B. $2.6.7 \times 10^{-4}$ *M*
C. 2.0×10^{-4} *M*
D. 4.0×10^{-5} *M*

Buffers: Common Ions

Equilibrium of Weak Acids-Bases

- Buffers are mixtures containing a common ion: either weak acids and their conjugate bases or weak bases and their conjugate acid.
- Two common buffers: ammonium-ammonia, carbonate-bicarbonate
- $NH_4^+(aq) \leftrightarrows H^+(aq) + NH_3(aq)$
- $CO_3^{-2}(aq) + H_2O(l) \leftrightarrows HCO_3^{-1}(aq) + OH^{-1}(aq)$

QUESTION

Which combinations will not serve as buffers when equal volumes of 0.20 M solutions are mixed?

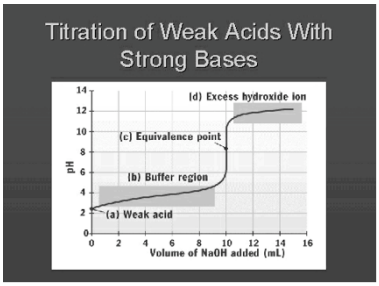
I) $HClO_4/KClO_4$ *II) HF/NaF*

III) NaH_2PO_4/Na_2HPO_4 *IV) HNO_3/KNO_3*

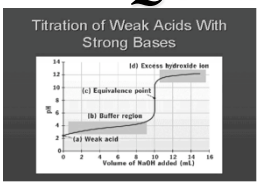
A) II and III ***B) III and IV*** ***C) I and III*** ***D) I and IV***

Buffers

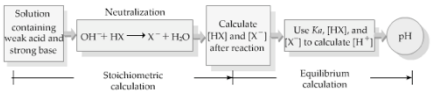
A Buffered Solution



QUESTION



What is the pH of a buffer solution made from adding 500. mL of 2.00 M $HOAc_{(aq)}$ ($Ka = 1.8 \times 10^{-5}$) to 100. mL of 5.100M $NaOH_{(aq)}$?



A) 4.74 B) 4.76 C) 9.24 D) 9.26

QUESTION

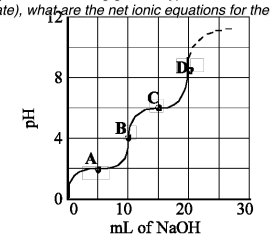
A certain chemical reaction runs very slow at high pH values and very fast at lower pH values. To study the reaction, a chemist needs to buffer the solution at a basic pH. Determine the pH of a buffer solution that had the following concentrations: 0.42 *M* NH_4Cl and 0.75 *M* NH_3; K_b of NH_3 = 1.8×10^{-5} at 25°C.

A.9.00
B.4.49
C.9.51
D.11.57

Titration Curves/ Buffers

Polyprotic Acids

H_2CO_3 has the following general type of titration curve (pH is not accurate), what are the net ionic equations for the two reactions?



•Where are the two buffer regions; the pH ranges?
A) A&B B) B&C C) C&D D) A&C E) none of the choices
•How many buffer ranges does phosphoric acid have?
A) one B) two C) three D) four E) none of the choices

Henderson-Hasselbalch Equation

- *Useful for calculating buffer concentrations (approximations) / pH using the $[A^-]/[HA]$ ratio.*

$$pH = pK_a + \log([A^-]/[HA]) =$$

$$pK_a + \log([base]/[acid])$$

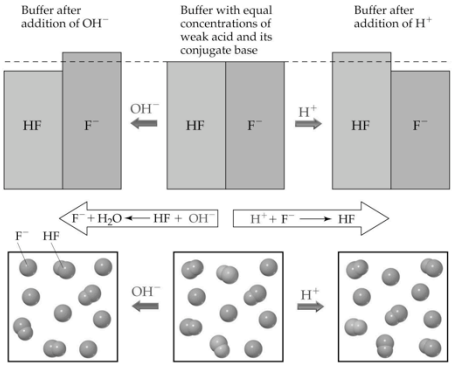
QUESTION

To culture a certain bacteria a microbiologist would like to buffer the media at a pH of 3.75. To maximize the efficiency of the system a 1:1 ratio of acid to salt will be used. Which of the following acids would make the best choice for the buffer?

A.Acetic acid; $K_a = 1.8 \times 10^{-5}$
B.Propanoic acid; $K_a = 1.3 \times 10^{-5}$
C.Formic acid; $K_a = 1.8 \times 10^{-4}$
D.Nitrous acid; $K_a = 4.0 \times 10^{-4}$

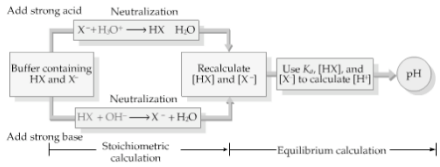
Buffered Solutions

- *They have relatively large amounts of a weak acid and its conjugate base; or, a weak base and its conjugate acid.*
- *They can be prepared by titration, or by adding a salt of the conjugate base of the weak acid to the weak acid; or a salt of the conjugate acid of the weak base to the weak base, and then adjusting.*
- *Add H^+ and it reacts to completion with the base.*
- *Add OH^- and it reacts to completion with the acid.*
- *The pH is determined by the ratio of the concentrations of the acid and base at equilibrium.*



A Buffered Solution

- *. . . resists change in its pH when either H^+ or OH^- are added.*
- *2.0 L of a buffer solution is prepared by adding 19.3 g of $NaF_{(s)}$ (MM=41.98 g/mol) and 500. ml of a 0.400 M solution of $HF_{(aq)}$ ($Ka= 6.8 \times 10^{-4}$) to a 2.0 L volumetric flask. Water is then added to make 2.0L of solution. What is the buffer's calculated pH?*
  A) 3.50 B) 3.53 C) 3.56 D) 3.59
- *What is the pH after adding 0.010 mol solid NaOH?*
  A) 3.50 B) 3.53 C) 3.56 D) 3.59
- *What is the pH after adding 20 drops of 10.M HCl to the original buffer solution? (1 drop = 0.05 mL)*
  A) 3.50 B) 3.53 C) 3.56 D) 3.59



QUESTION

A 0.50 L buffer solution containing 0.42 *M* NH_4Cl and 0.75 M NH_3 (K_b of $NH_3 = 1.8 \times 10^{-5}$) has a pH of 9.51 at 25°C. The solution receives 0.010 moles of HCl from an outside source. Assuming no significant change in volume of the solution, what is the pH of the solution after the addition of the HCl at 25°C?

A.9.48
B.9.51
C.9.34
D.8.76

Buffering Capacity

- *. . . represents the amount of H^+ or OH^- that a buffer can absorb without a significant change in pH.*
- *….governed by mass balance (moles).*

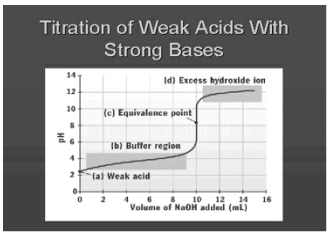
QUESTION

Two separate buffer solutions are prepared using propanoic acid and calcium propanoate (also used as a food preservative). If buffer "A" was 0.10 *M* in both acid and salt while buffer "B" was 0.20 *M* in both acid and salt, which of the following would be true?

A. Both solutions would have the same pH and would have the same buffer capacity.
B. Solution "B" would would have a lower pH and both would have the same buffer capacity.
C. Solution "B" would have a lower pH and a larger buffer capacity.
D. Both solutions would have the same pH; "B" would have a larger buffer capacity.

A Buffered Solution

If 10. mL of a 0.10M buffer pH=4 is treated with 15.mL of 0.10M NaOH, will the buffer still work? YES(A)/ NO(B)



Buffer Systems (human & environmental)

H_2CO_3(aq) / HCO_3^{-1}(aq) / CO_3^{-2}(aq)

Two VERY IMPORTANT Complex Bicarbonate Buffer Systems

CO_2(g) + H_2O (l) ⇆ HCO_3^{-1}(aq) + H^{+1}(aq) ⇆ CO_3^{-2}(aq) + H^{+1}(aq)

1. *Blood: a human's blood serum volume is relatively small, 4-6 Liters. pH = 7.35 – 7.45 (homeostasis)*
   - *Ever had respiratory alkalosis?*

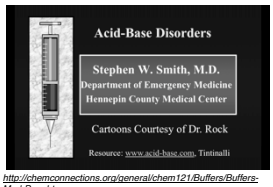
2.Oceans: an extraordinarily large volume "salt water" solution. pH = 8.1 and falling

http://www.tos.org/oceanography/issues/issue_archive/22_4.html

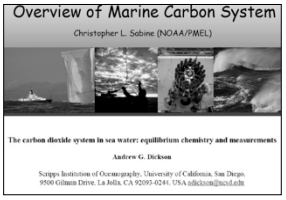
- *Increasing CO_2 , decreasing ocean pH, long term effects? Coral reefs?*

http://sos.noaa.gov/datasets/Ocean/ocean_acidification.html

Human & Oceanic Bicarbonate Buffer Systems
Adapted Presentations



http://chemconnections.org/general/chem121/Buffers/Buffers-Med-Pres.htm



http://chemconnections.org/general/chem121/Buffers/Buffers-CO2-Oceans-2011.htm