CONCEPT: BUFFERS

A buffer is a solution composed of a weak acid with its conjugate base.

HClO + **NaClO (aq)**

Weak oxyacid — **Conjugate base**

(Has 1 less Hydrogen)

- A buffer works to keep both _____ and _____ constant.

If a ***strong base*** then the buffer resists a pH change by having the ***weak acid*** neutralize it.

HClO (aq) + **NaOH (aq)** ⟶ **NaClO (aq)** + **H_2O (l)**

Weak oxyacid — **Strong Base**

If a ***strong acid*** then the buffer resists a pH change by having the ***conjugate base*** neutralize it.

NaClO (aq) + **HCl (aq)** ⟶ **HClO (aq)** + **NaCl (l)**

Conjugate Base — **Strong Acid**

The weak acid and conjugate base can be different from one another by up to a magnitude of 10.

- This is called the _____ . If they are different by more than 10 then it will not be a buffer.

1.0 M HClO + **0.10 M NaClO (aq)** } **Weak Acid is 10 times the amount of the conjugate base**

Weak oxyacid — **Conjugate base**

0.05 M HClO + **0.50 M NaClO (aq)** } **Conjugate base is 10 times the amount of the weak acid**

Weak oxyacid — **Conjugate base**

The more concentrated the weak acid and conjugate base then the better the buffer can counteract strong acid or strong base added.

1.0 M HClO + **1.0 M NaClO (aq)**

Weak oxyacid — **Conjugate base**

0.01 M HClO + **0.01 M NaClO (aq)**

Weak oxyacid — **Conjugate base**

CONCEPT: BUFFER SYNTHESIS

To calculate the pH of a buffer then we use the Henderson Hasselbalch Equation:

$$pH = pKa + \log\frac{\text{conjugate base}}{\text{weak acid}}$$

There are **3** ways to form a buffer:

1) Mixing a _____ acid and a _____ base.

- In this case, a buffer is most ideal when both components are highly concentrated and equal to one another.

0.10 M HClO (Weak oxyacid) **+** **0.10 M NaClO (aq)** (Conjugate base) } **Ideal Buffer** — Weak Acid & Conjugate Base Equal in Concentrations

2) Mixing a _____ acid and a _____ base.

- In this case since we have a strong species mixing with a weak species then we must make sure the weak species is higher in amount.

1.0 M HCl (Strong Binary Acid) **+** **1.25 M NH_3 (aq)** (Weak Base) } **Buffer Created** — Weak base is greater in amount

1.50 M HCl (Strong Binary Acid) **+** **1.25 M NH_3 (aq)** (Weak Base) } **No Buffer Created** — Strong Acid is greater in amount

3) Mixing a _____ acid and a _____ base.

- In this case since we have a strong species mixing with a weak species then we must make sure the weak species is higher in amount.

1.50 moles HNO_2 (Weak Oxyacid) **+** **1.25 moles NaOH (aq)** (Strong Base) } **Buffer Created** — Weak acid is greater in amount

1.00 moles HNO_2 (Weak Oxyacid) **+** **1.10 moles NaOH (aq)** (Strong Base) } **No Buffer Created** — Strong Base is greater in amount

PRACTICE: BUFFER SYNTHESIS CALCULATIONS 1

EXAMPLE 1: Which of the following combinations can result in the formation of a buffer?

a) 75 mL of 0.10 M $HClO_3$ with 50 mL of 0.10 M CH_3NH_2.

b) 25 mL of 0.10 M H_2SO_3 with 40.0 mL of 0.10 M NaOH.

c) 50 mL of 0.10 M NH_4Cl with 50 mL of 0.05 M $Sr(OH)_2$.

d) 50 mL of 0.20 M HF with 40 mL of 0.20 M NaOH.

EXAMPLE 2: Calculate the pH of a solution formed by mixing 130.0 mL of a 0.300 M $C_2H_5NH_2$ solution with 70.0 mL of a 0.500 M $C_2H_5NH_3^+$ solution. (K_b of $C_2H_5NH_2$ is 5.0×10^{-4}).

PRACTICE: Which of the following molar ratios is the correct equilibrium ratio of BASE : ACID for a solution made of aniline (Kb = 3.8×10^{-10}) and anilinium nitrate where the pH is 4.80?

a) 1:2

b) 3:5

c) 7:2

d) 2:1

e) 5:3

PRACTICE: BUFFER SYNTHESIS CALCULATIONS 2

EXAMPLE 1: You are asked to go into the lab and prepare a buffer solution with a pH of 6.40 ± 0.2. Which weak acid would be the best choice?

a) carbonic acid $K_a = 4.2 \times 10^{-7}$

b) phenol $K_a = 1.3 \times 10^{-10}$

c) ascorbic acid $K_a = 8.0 \times 10^{-5}$

d) hydrosulfuric acid $K_a = 9.5 \times 10^{-8}$

e) potassium hydrogen phthalate $K_a = 3.1 \times 10^{-6}$

EXAMPLE 2: Calculate the pH of a solution made by mixing 8.627 g of sodium butanoate in enough 0.452 M butanoic acid, $HC_4H_7O_2$, to make 250.0 mL of solution. The K_a of butanoic acid is 1.5×10^{-5}.

a) 4.75

b) 4.82

c) 5.00

d) 2.58

e) 4.65