Buffer Solutions

A buffer is a solution that can resist pH change upon the addition of an acidic or basic components. It is able to neutralize small amounts of added acid or base, thus maintaining the pH of the solution relatively stable. This is important for processes and/or reactions which require specific and stable pH ranges.

Buffer in solutions

The pH of water and most solutions changes drastically when a small amount of acid or base is added.

However, when an acid or base is added to a buffer solution, there is little change in pH.

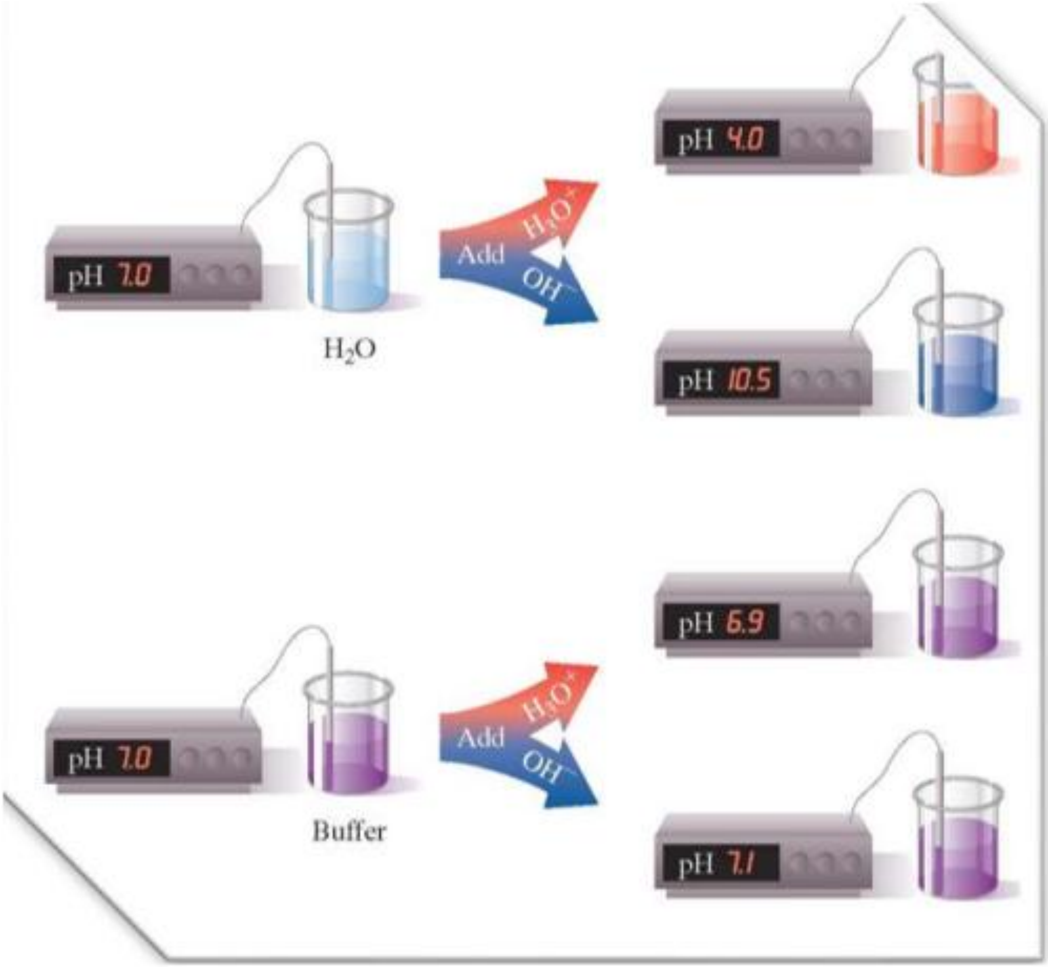
A buffer solution maintains pH by neutralizing small amounts of added acid or base.

Buffers may also contain a weak base and a salt containing its conjugate acid.

For example, blood contains buffers that maintain a consistent pH of about 7.4 .

If the pH of the blood goes slightly above or below 7.4, changes in oxygen levels and metabolic processes can be drastic enough to cause death.

Even though we obtain acids and bases from foods and cellular reactions, the buffers in the body absorb those compounds so effectively that the pH of the blood remains essentially unchanged (see Figure 1)



Sample problem 1 : indicate whether each of the following would make a buffer solution:

a. HCl and NaCl

b. KOH and KCl

c. HF and NaF

Buffers in the Body :

* The arterial blood has a normal pH of 7.35 to 7.45.

* If changes in H_3O^+ lower the pH below 6.8 or raise it above 8.0, cells cannot function properly and death may result.

* In our cells, CO_2 is continually produced as an end product of cellular metabolism.

* Some CO_2 is carried to the lungs for elimination, and the rest dissolves in body fluids such as plasma and saliva, forming carbonic acid.

* As a weak acid, carbonic acid ionizes to give bicarbonate, HCO_3^- and H_3O^+

* More of the anion HCO_3^- is supplied by the kidneys to give an important buffer system in the body fluid: the H_2CO_3 /HCO_3^- buffer.

$$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$$

- Excess H_3O^+ entering the body fluids reacts with the HCO_3^- and excess OH^- reacts with the carbonic acid.

$$H_2CO_3(aq) + H_2O(l) \longleftarrow H_3O^+(aq) + HCO_3^-(aq)$$

Equilibrium shifts in the direction of the reactants

$$H_2CO_3(aq) + OH^-(aq) \longrightarrow H_2O(l) + HCO_3^-(aq)$$

Equilibrium shifts in the direction of the products

- In the body, the concentration of carbonic acid is closely associated with the partial pressure of CO_2.

If the CO_2 level increases, it produces more H_2CO_3 and more H_3O^+, lowering the pH.

A condition called acidosis

A decrease in the CO2 level leads to a high blood pH, a condition called **alkalosis**.

Qeustion

1. Which of the following represents a buffer system? Explain.

a. NaOH and NaCl **b.** H_2CO_3 and $NaHCO_3$
c. HF and KF **d.** KCl and NaCl

2. Which of the following represents a buffer system? Explain.

a. H_3PO_3 **b.** $NaNO_3$
c. $HC_2H_3O_2$ and $NaC_2H_3O_2$ **d.** HCl and NaOH.

- **3. Consider the buffer system of hydrofluoric acid, HF, and its salt, NaF.**

$$HF(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + F^-(aq)$$

- **a.** The purpose of this buffer system is to:
- **1.** maintain [HF] **2.** maintain [F^-]
  3. maintain pH

- **b.** The salt of the weak acid is needed to:
1. provide the conjugate base
2. neutralize added H_3O^+
3. provide the conjugate acid

- **c.** If OH" is added, it is neutralized by:
  1. the salt **2.** H_2O **3.** H_3O^+
- **d.** When H_3O^+ is added, the equilibrium shifts in the direction of the:

1. Reactants **2.** Products **3.** does not change

4.Consider the buffer system of nitrous acid, HNO_2, and its salt, $NaNO_2$-

$$HNO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$$

a.The purpose of this buffer system is to:

1. maintain $[HNO_2]$ **2.** maintain $[NO_2^-]$ **3.** maintain pH

b.The weak acid is needed to:

1. provide the conjugate base
2. neutralize added OH"
3. provide the conjugate acid

c. If H_3O^+ is added, it is neutralized by:

1. the salt **2.** H_2O **3.** OH^-

d.When OH" is added, the equilibrium shifts in the direction of the:

1. reactants **2.** Products **3.** does not change

$$pH = pKa + \log \frac{[salt]}{[acid]}$$

$$pOH = pKb + \log \frac{[salt]}{[base]}$$

What is the pH of a solution containing 0.02 M HA and 0.01 M A^-? pKa of HA = 5.0.

$$pH = pKa + \log \frac{[salt]}{[acid]}$$

$$pH = 5 + \log \frac{0.01}{0.02}$$

$$pH = 5 + \log 0.5$$
$$pH = 4.69$$

1.0 What is the pH of 50.00 mL buffer solution which is 2.00M in $HC_2H_3O_2$ and 2.00M in $NaC_2H_3O_2$? What is the new pH after 2.00 mL of 6.00M HCl is added to this buffer ?

What is the new pH after 2.00 mL of 6.00M NaOH is added to the **original** buffer?

Calculate the pH of a buffer solution prepared by dissolving 0.10 mole of cyanic acid, HCNO, and 0.50 mole of sodium cyanate, NaCNO, in enough water to make 0.500 liter of solution. For HCNO, $K_a = 2.0 \times 10^{-4}$ at 25°C.