Marks
5

- The primary buffering system in blood plasma is represented by the following equation:

$$H_2CO_3 \rightleftharpoons HCO_3^- + H^+ \qquad pK_a = 6.1$$

What is the ratio HCO_3^- : H_2CO_3 at the normal plasma pH of 7.4?

The Henderson-Hasselbalch equation with [acid] = [H_2CO_3] and [base] = [HCO_3^-] can be used for this buffer system,

$$pH = pK_a + \log_{10}\left(\frac{[base]}{[acid]}\right)$$

$$= 6.1 + \log_{10}\left(\frac{[base]}{[acid]}\right) = 7.4$$

$$\frac{[base]}{[acid]} = 10^{(7.4-6.1)} = 10^{1.3} = 20$$

Answer: **[base] : [acid] = 20 : 1**

A typical person has 2 L of blood plasma. If such a person were to drink 1 L of soft drink with a pH of 2.5, what would the plasma pH be if it were not buffered? (Assume all of the H^+ from the soft drink is absorbed by the plasma, but the volume of plasma does not increase.)

As pH = $-\log_{10}[H^+]$, the [H^+] in the soft drink is,

$$[H^+]_{soft\ drink} = 10^{-2.5}\ M$$

1 L of soft drink therefore contains

$$\text{number of moles} = \text{concentration} \times \text{volume} = (10^{-2.5}\ mol\ L^{-1} \times 1\ L) = 10^{-2.5}\ mol$$

If this amount is present in 2 L of plasma,

$$[H^+]_{plasma} = \frac{\text{number of moles}}{\text{volume}} = \frac{10^{-2.5}}{2}\ M$$

Hence the pH of the unbuffered plasma is

$$pH = -\log_{10}[H^+] = -\log_{10}\left(\frac{10^{-2.5}}{2}\right) = 2.8$$

Answer: **2.8**

ANSWER CONTINUES ON THE NEXT PAGE

What is the pH in this typical person with a normal HCO_3^- concentration of 0.020 M? Ignore any other contributions to the buffering.

Before the addition of the soft drink, $[HCO_3^-]$ = 0.020 M and, at pH 7.4, $[H_2CO_3]$ = $[HCO_3^-]$ / 20 = 0.0010 M.

As the soft drink has $10^{-2.5}$ mol of H^+, its concentration when added to the plasma will again be $[H^+] = \frac{10^{-2.5}}{2}$ M before buffering. Adding it will decrease the base concentration and increase the acid concentration so that,

$$[HCO_3^-] = \left(0.020 - \frac{10^{-2.5}}{2}\right) \text{M} = 0.018 \text{ M}$$

$$[H_2CO_3] = \left(0.0010 + \frac{10^{-2.5}}{2}\right) \text{M} = 0.0026 \text{ M}$$

Hence,

$$\text{pH} = (6.1) + \log_{10}\left(\frac{0.018}{0.0026}\right) = 7.0$$

Answer: **7.0**