ACID-BASE Problem, # 1[i] -- SOLUTIONS

Bio390

1. Calculate the ratio in which $Na^{+}H_2PO_4^{-}$ and $Na_2^{+}HPO_4^{=}$ must be mixed to give a buffer solution of pH equal to 7.0. The pKa for this buffer is 7.21.

$$pH = pKa + \log\left(\frac{\text{"salt"}}{\text{"acid"}}\right)$$

$$\log\left(\frac{\text{"salt"}}{\text{"acid"}}\right) = pH - pKa$$

$$\frac{\text{"salt"}}{\text{"acid"}} = 10\text{\^{}}(pH - pKa)$$

$$= 10\text{\^{}}(7 - 7.21) = 0.62$$

ANSWER: $\frac{\text{"salt"}}{\text{"acid"}} = 0.62$

Notice that the *p*H in this case is less than the *pKa* and, as we would expect, there is more acid than base in this condition.

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[i] thanks to Dr. J.F. Anderson, Dept Zoology, Univ of Florida, Gainesville for the original idea for this problem

2. You are provided with the following values relative to the regulation of plasma *p*H in a mammal.

NORMAL VALUES:

*p*H : 7.40

pKa (carbonic acid-bicarbonate buffer): 6.10

α for CO_2 at body temperature: $\frac{0.03\ \text{mmols}}{\text{L . mm Hg}}$

P_{CO2} (in systemic arterial plasma): 40 mmHg

a. Would you expect an increase or decrease in plasma bicarbonate concentration during **uncompensated** respiratory alkalosis? Explain!

In uncompensated respiratory alkalosis, the total amount of bicarbonate/carbonic acid buffer system has been reduced by the hyperventilation that is causing thialkalosis. Thus, the P_{aCO2} will be lower than normal and as a result there will be less HCO_3^- - than normal. However, the ratio of the CO_2 to bicarbonate will be more in favor of bicarbonate and there will be less H^+ than normal; thus the alkalosis.

b. Estimate the plasma bicarbonate concentration if the kidney regulated the concentration of this salt to bring pH back to 7.4 during **compensation** of respiratory alkalosis at P_{aCO2} of **22 mm Hg**.

We assume that the condition that causes the respiratory alkalosis continues (or else we wouldin't talk about compensation but instead a return to normal). Thus, in compensation, the *p*H = 7.4 (normal) and the respiratory problem continues with a P_{aCO2} = 22 torr. Solving the H-H equation:

$$pH = pKa + \log\left(\frac{[HCO_3^-]}{\alpha P_{CO2}}\right)$$

$$\log\left(\frac{[HCO_3^-]}{\alpha P_{CO2}}\right) = pH - pKa$$

$$\frac{[HCO_3^-]}{\alpha P_{CO2}} = 10\verb|^|(pH - pKa)$$

$$[HCO_3^-] = \alpha P_{CO2} * (10\verb|^|(pH - pKa))$$

$$= \frac{0.03 \text{ mmols}}{\text{L . mm Hg}} * 22 * (10\verb|^|(7.4-6.1))$$

$[HCO_3^-]$ **= 13.2 mM**

Notice that 13.2 mM is considerably below the normal arterial [HCO_3^-] of 24 mM. Recall that the compensation requires that in this case we "slide down" the P_{aCO2} = 22 torr isopleth, in the process reducing the [HCO_3^-] until we get back to a 20:1 ratio of bicarbonate to acid. Once again, the total concentration of the buffer system has been reduced, in this case both by the hyperventilation and further by secretion of bicarbonate by the kidney and reabsorption of protons: