Deacon's Challenge No. 6 Answer

Calculate the amount in grams of lactic acid which must be added to 2.0 grams of sodium hydroxide to give 1 litre of a solution with a pH of 4.0 (the pKa of lactic acid is 3.86 and the atomic weight of sodium 23).

(MRCPath November, 1989)

First calculate the molar concentration of sodium hydroxide:

MW NaOH = 23 + 16 + 1 = 40

$$\text{Molar concentration} = \frac{\text{concentration (g/L)}}{\text{MW}} = \frac{2.0}{40} = 0.05 \text{ mol/L}$$

The following reaction occurs between lactic acid (LactH) and NaOH:

$$\text{LactH} + \text{NaOH} \rightarrow \text{LactNa} + H_20$$

Both sodium lactate and lactic acid can dissociate to form lactate ions:

$$\text{LactNa} \rightarrow \text{Lact}^- + \text{Na}^+$$

$$\text{LactH} \leftrightarrow \text{Lact}^- + \text{H}^+$$

The relationship between the concentration of the species Lact^- and LactH is governed by the Henderson Hasselbalch equation:

$$pH = pK_a + \log_{10} \frac{[\text{Lact}^-]}{[\text{LactH}]}$$

In order to make use of this equation it is necessary to assume that the concentration of Lact^- is the same as sodium, i.e.

1. That sodium lactate is completely dissociated, and

2. That the portion of Lact^- that derives from lactic acid is negligible compared to that derived from sodium lactate. This portion will be the same as the hydrogen ion concentration which can be calculated from the pH and is 0.0001 mol/L - obviously insignificant compared to 0.05 mol/L.

Therefore substitute 3.86 for the pKa of lactic acid, 4.0 for pH and 0.05 for the molar concentration of Lact^- into the Henderson Hasselbalch equation and solve for [LactH]:

$$4.0 = 3.86 + \log_{10} \frac{0.05}{[\text{LactH}]}$$

$$\log_{10} \frac{0.05}{[\text{LactH}]} = 4.0 - 3.86 = 0.14$$

$$\frac{0.05}{[\text{LactH}]} = \text{antilog } 0.14 = 1.380$$

$$[\text{LactH}] = \frac{0.05}{1.380} = 0.036 \text{ mol/L}$$

The total lactate needed is the sum of the ionized and unionized acid:

$$\text{Total } [\text{Lact}^-] = [\text{LactH}] + [\text{Lact}^-] = 0.036 + 0.05 = 0.086 \text{ mol/L}$$

Convert to the weight of lactic acid required:

Wt of lactic acid (g/L) = conc (mol/L) x MW

MW of lactic acid (formula $C_3H_6O_3$) = (3 x 12) + (6 x 1) + (3 x 16) = 90

Wt of lactic acid required = 0.086 x 90 = 7.74 g ■

Question No. 7

In health, most of sodium filtered by the glomeruli is reabsorbed at various sites along the nephron.

Estimate the effect on urinary sodium excretion in a person with otherwise normal renal function of a 1% decrease in the overall reabsorption of sodium, indicating any assumptions that you make.

(MRCPath November 1999)