Deacon's Challenge No. 73 Answer

You need to make up a phosphate buffer with a pH of 7.4 and a total phosphate concentration of 50 mmol/L. Calculate the amounts of sodium dihydrogen phosphate and disodium monohydrogen phosphate that need to be weighed into 1 litre of water, given that the pKa is 6.82 (atomic weights: Na 23, P 31).

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The relevant dissociation is:

$$H_2PO_4^- \longleftrightarrow HPO_4^{2-} + H^+$$

The relationship between the concentrations of the two phosphate species and pH is described by the Henderson-Hasselbalch equation:

$$pH = pK_a + \log_{10} \frac{[HPO_4^{2-}]}{[H_2PO_4^-]}$$

First substitute pH = 7.4 and pK_a = 6.82 in order to calculate the ratio of the concentrations of the two phosphate species:

$$7.4 = 6.82 + \log_{10} \frac{[HPO_4^{2-}]}{[H_2PO_4^-]}$$

$$\log_{10} \frac{[HPO_4^{2-}]}{[H_2PO_4^-]} = 7.4 - 6.82 = 0.58$$

$$\frac{[HPO_4^{2-}]}{[H_2PO_4^-]} = \text{antilog}_{10}\, 0.58 = 3.80$$

We are told that the total phosphate concentration is 50 mmol/L (= 0.05 mol/L). Therefore:

$$[HPO_4^{2-}] + [H_2PO_4^-] = 0.05 \text{ mol/L}$$

Next express the concentration of one of the phosphate species in terms of the other and the total phosphate concentration (it doesn't matter which):

$$[HPO_4^{2-}] = 0.05 - [H_2PO_4^-]$$

Then insert this value into the ratio at pH 7.4 and solve for $[H_2PO_4^-]$:

$$\frac{0.05 - [H_2PO_4^-]}{[H_2PO_4^-]} = 3.80$$

$$0.05 - [H_2PO_4^-] = 3.80\,[H_2PO_4^-]$$

$$3.80\,[H_2PO_4^-] + [H_2PO_4^-] = 0.05$$

$$4.80\,[H_2PO_4^-] = 0.05$$

$$[H_2PO_4^-] = \frac{0.05}{4.80} = 0.0104 \text{ mol/L}$$

The concentration of the other phosphate species is obtained by subtraction of this value from the total phosphate:

$$[HPO_4^{2-}] = 0.05 - 0.0104 = 0.0396 \text{ mol/L}$$

The amount of each phosphate to be weighed out to prepare 1 litre of buffer is obtained by multiplication of each molar concentration by its molecular weight:

Concentration (g/L) = Concentration (mol/L) x Molecular weight (MW)

MW NaH_2PO_4 = 23 + (2 x 1) + 31 + (4 x 16) = 120

MW Na_2HPO_4 = (2 x 23) + 1 + 31 + (4 x 16) = 142

Weight of NaH_2PO_4 = 0.0104 x 120 = **1.248g**

Weight of Na_2HPO_4 = 0.0396 x 142 = **5.623g**

Question 74

Calculate the loading dose of intravenous aminophylline required to achieve a plasma theophylline concentration of 15 mg/L in a 55 Kg man, given that the volume of distribution of theophylline is 0.5 L/Kg and that aminophylline is 80% w/w theophylline. What infusion rate would be required to maintain this concentration if the half-life is 8 hours?

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