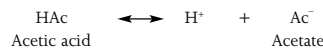# Deacon's Challenge No. 65 Answer

The pKa of acetic acid is 4.76. What volume of 0.2 mmol/L acetic acid should be added to 80 mL 0.2 mmol/L sodium acetate to give a buffer with a pH of 5.8. Comment on the buffer capacity of this buffer.

MRCPath, November 2005

The dissociation of acetic acid is:

$$HAc \longleftrightarrow H^+ + Ac^-$$

Acetic acid   Acetate

Which can be described by the Henderson-Hasselbach equation:

$$pH = pK_a + \log_{10} \frac{[Ac^-]}{[HAc]}$$

Substitute pH 5.8, $pK_a = 4.76$ and solve for $[Ac^-]/[HAc]$:

$$5.8 = 4.76 + \log_{10} \frac{[Ac^-]}{[HAc]}$$

$$\log_{10} \frac{[Ac^-]}{[HAc]} = 5.8 - 4.76 = 1.04$$

$$\frac{[Ac^-]}{[HAc]} = \text{antilog}_{10}\, 1.04 = 11.0 \quad \text{(3 sig figs)}$$

Therefore the concentration of acetic acid is one eleventh the concentration of sodium acetate (the small amount of acetate which derives from the dissociation of acetic acid can be ignored). Since the concentrations of acetic acid and sodium acetate stock solutions are identical (0.2 mmol/L) the volume of acetic acid required is 80/11 = **7.27 mL**.

A buffer has its maximum buffering capacity when the pH is equal to its pKa value (when [salt] = [acid] and the ratio of [salt]/[acid] = 1). Buffering involves inter-conversion of salt and acid (depending upon whether it is acid or base which is being buffered), with a minimum change in the ratio of [salt] to [acid]. The pH of this buffer (5.8) is approximately one pH unit above its pKa (4.76) so that [salt]>>[acid] with a [salt]/[acid] of 11. Therefore buffering of a similar amount of added acid or base, although producing the same absolute changes in [salt] and [acid], will have a much greater effect on their ratio and hence the pH of the buffer. Therefore at pH 5.80 this buffer will have a very poor buffering capacity. In general the usefulness of a buffer is limited to the range encompassing its pKa ± 1 pH unit. ■

Question 66

A subject was infused with a drug at the rate of 12 mmol/h until a plasma steady state concentration of 200 μmol/L was reached.

Calculate, and comment on, the clearance of the drug.