

# Deacon's Challenge

## No 103 - Answer

*It is becoming increasingly common practice to replace pH with hydrogen ion concentration when reporting acid-base data. A patient is admitted to ITU with a blood hydrogen ion concentration of 80 nmol/L, pCO<sub>2</sub> of 5.4 kPa and an actual bicarbonate of 12 mmol/L. After taking steps to improve ventilation and circulation a second set of blood gases were: pCO<sub>2</sub> 5.1 kPa and bicarbonate 20 mmol/L. Calculate the new hydrogen ion concentration in nmol/L.*

*FRCPath, Spring 2009*

It is possible to solve this problem by using the Henderson-Hasselbalch equation to determine the new pH then converting the result back to hydrogen ion concentration. However it is much simpler to use the relationship between the hydrogen ion concentration, pCO<sub>2</sub> and bicarbonate concentration:

$$K = \frac{[H^+] \times [HCO_3^-]}{pCO_2}$$

where  $K$  is a constant with components from the equilibrium constants for carbonic acid formation and dissociation, water concentration and the Bunsen solubility coefficient for CO<sub>2</sub>.

Therefore the parameters both before and after treatment are related:

$$\frac{\text{Initial } [H^+] \times \text{Initial } [HCO_3^-]}{\text{Initial } pCO_2} = \frac{\text{Final } [H^+] \times \text{Final } [HCO_3^-]}{\text{Final } pCO_2}$$

It does not matter if the units for the individual components differ as long as they are the same on both sides of the equation.

Rearrangement gives the following expression for the final hydrogen ion concentration:

$$\text{Final } [H^+] = \frac{\text{Initial } [H^+] \times \text{Initial } [HCO_3^-] \times \text{Final } pCO_2}{\text{Initial } pCO_2 \times \text{Final } [HCO_3^-]}$$

|                         |  |   |           |  |                 |
|-------------------------|--|---|-----------|--|-----------------|
| Substitute:             | Initial [H <sup>+</sup> ]                | =   | 80 nmol/L |  |                 |
|                         | Initial pCO <sub>2</sub>                 | =   | 5.4 kPa   | Final pCO <sub>2</sub>                 | = 5.1 kPa       |
|                         | Initial [HCO <sub>3</sub> <sup>-</sup> ] | =   | 12 mmol/L | Final [HCO <sub>3</sub> <sup>-</sup> ] | = 20 mmol/L     |
| Final [H <sup>+</sup> ] | =  | $\frac{80 \times 12 \times 5.1}{5.4 \times 20}$ | =         | 45 nmol/L                              | (to 2 sig figs) |

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## Question 104

A patient who weighed 75 Kg presented with rapid atrial fibrillation. He was given a first 250 µg oral dose of digoxin on admission. Twelve hours later he is reviewed by a cardiologist who notes that he is still in atrial fibrillation and recommends a loading dose of digoxin in order to bring his next pre-dose plasma digoxin concentration to approximately 1.5 µg/L 12 hours later. Calculate the dose that should now be given. Assume the following:

- Digoxin volume of distribution 7.3 L/Kg
- Oral bioavailability 0.62
- Single first order half life of 36 hours

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