Marks 5

- The concentration of a dissolved gas is related to its partial pressure by c = *k*p. What is the concentration of CO_2 dissolved in blood if the partial pressure of CO_2 in the lungs is 0.053 atm? The *k* for CO_2 is 0.034 mol L^{-1} atm^{-1}.

Using *c* = *k*p,

***c* = (0.034 mol L^{-1} atm^{-1})(0.053 atm) = 0.0018 mol L^{-1}**

Answer: **0.0018 mol L^{-1}**

Calculate the pH of blood if all of this CO_2 reacted to give H_2CO_3.
The K_a of H_2CO_3 is 4.5×10^{-7}.

If $[H_2CO_3(aq)]$ = 0.0018 mol L^{-1}, the pH can be calculated using the reaction table:

	H_2CO_3	H_2O	⇌	H_3O^+	HCO_3^-
initial	**0.0018**	**large**		**0**	**0**
change	**-*x***	**negligible**		**+*x***	**+*x***
final	**0.0018 – *x***	**large**		***x***	***x***

The equilibrium constant K_a is given by:

$$K_a = \frac{[H_3O^+][HCO_3^-]}{[H_2CO_3]} = \frac{x^2}{0.0018 - x}$$

As $K_a = 4.5 \times 10^{-7}$ and is very small, $0.0018 - x \sim 0.0018$ and hence:

$$x^2 = 0.0018 \times (4.5 \times 10^{-7}) \quad \text{or} \quad x = 2.8 \times 10^{-5}\ M = [H_3O^+]$$

Hence:

$$pH = -\log_{10}[H_3O^+(aq)] = -\log_{10}(2.8 \times 10^{-5}) = 4.54$$

Answer: **4.54**

Hyperventilation results in a decrease in the partial pressure of CO_2 in the lungs. What effect will this have on the pH of the blood? Use a chemical equation to illustrate your answer.

If the CO_2 partial pressure decreases, the equilibrium below will shift to the left. This will decrease $[H^+(aq)]$ and the pH will increase.

$$CO_2(aq) + H_2O \rightleftharpoons H_2CO_3(aq) \rightleftharpoons HCO_3^-(aq) + H^+(aq)$$

ANSWER CONTINUES ON THE NEXT PAGE

The pH of blood is maintained around 7.4 by the H_2CO_3 / HCO_3^- buffer system. Explain how a buffer works, illustrating your answer with chemical equations.

A buffer resists changes in pH. It contains substantial quantities of a weak acid and its conjugate base. In the H_2CO_3/HCO_3^- buffer, added acid is removed by the reaction:

$$\mathbf{HCO_3^-(aq) + H^+(aq) \rightarrow H_2CO_3(aq)}$$

Added base is removed by the reaction:

$$\mathbf{H_2CO_3(aq) + OH^-(aq) \rightarrow HCO_3^-(aq) + H_2O}$$