Deacon's Challenge

No 159 - Answer

Calculate the pH of an aqueous 0.25 % w/v solution of sodium lactate. (The pKa of lactic acid is 3.86 and the atomic weights are C = 12, H =1, O = 16 and Na = 23).

First calculate the molar concentration of sodium lactate:

$$\text{Conc (mol/L)} = \frac{\text{Conc (g/L)}}{\text{MW}}$$

Conc (g/L) = Conc (g/100 mL) x 10 = 0.25 x 10 = 2.5 g/L

MW sodium lactate (formula CH_3- CH(OH)-COONa = $C_3H_5O_3Na$)

= (3 x 12) + (1 x 5) + (3 x 16) + 23 = 112

$$\text{Conc (mol/L)} = \frac{2.5}{112} = 2.23 \times 10^{-2} \text{ mol/L}$$

Sodium lactate is the salt of a weak acid and in aqueous solution undergoes salt hydrolysis:

$$\text{Na Lact (solid)} \longrightarrow \text{Na}^+ \text{ (aqueous)} + \text{Lact}^- \text{ (aqueous)}$$

$$\text{Lact}^- + H_2O \longrightarrow \text{LactH} + OH^-$$

The lactate ion functions as a weak base and its equilibrium constant is denoted K_b:

$$K_b = \frac{[\text{LactH}][OH^-]}{[\text{Lact-}]}$$

(The concentration of water is very large and relatively constant and so is incorporated into the value of K_b)

The relationship between K_a and K_b for any conjugate acid-base pair is:

$$\boxed{K_a \times K_b = K_w}$$

where K_w is the ionization constant for water and has the value 1×10^{-14}

Use this relationship to calculate the K_b of lactate from its K_a:

$$K_a = \text{antilog}_{10}(-\text{pKa}) = \text{antilog}_{10}(-3.86) = 1.38 \times 10^{-4}$$

$$K_b = \frac{K_w}{K_a} = \frac{1 \times 10^{-14}}{1.38 \times 10^{-4}} = 7.25 \times 10^{-11}$$

If *x* is the amount of lactate that reacts with water then the amount of lactic acid and hydroxide ion is also *x* and the remaining amount of lactate ion is $(2.23 \times 10^{-2}) - x$ mol/L:

$$\underset{(2.23 \times 10^{-2}) - x}{\text{Lact}^-} + H_2O \longrightarrow \underset{(x)}{\text{LactH}} + \underset{(x)}{OH^-}$$

and the expression for the equilibrium constant can be written:

$$K_b = 7.25 \times 10^{-11} = \frac{(x) \times (x)}{(2.23 \times 10^{-2}) - x} = \frac{x^2}{(2.23 \times 10^{-2}) - x}$$

This is a quadratic equation which could be solved for *x* in the usual way. However, since lactate is a very weak base, *x* is very small its value can be omitted from the denominator making the solution easier:

$$7.25 \times 10^{-11} = \frac{x^2}{2.23 \times 10\text{-}2}$$

$$x^2 = 7.25 \times 10^{-11} \times 2.23 \times 10^{-2} = 1.62 \times 10^{-12}$$

$$x = \sqrt{(1.62 \times 10\text{-}12)} = 1.27 \times 10^{-6} \text{ mol/L}$$

x is the concentration of hydroxide ions in mol/L which can be converted to its pOH:

$$\text{pOH} = -\log_{10}[OH^-] = -\log_{10}(1.27 \times 10^{-6}) = -(0.104 - 6) = -(-5.90) = 5.90$$

The pH can be calculated from the relationship between pH and pOH:

$$\boxed{\text{pH} + \text{pOH} = 14}$$

pH = 14 - pOH = 14 - 5.90 = **8.10**

Question 160

As part of the evaluation of an immunoassay for a renal tubular protein a recovery experiment was performed by spiking 500 µL of urine with 50 µL of protein standard containing 2000 pg/mL. Assay of the unadulterated urine and urine/standard mixture gave values of 210 pg/mL and 350 pg/mL respectively. Calculate the percentage recovery and determine if it is significantly different from 100%. Assume there was no error involved in spiking the urine and the analytical standard deviation is 10 pg/mL.

Table of *z*-distribution:

P(%)	10	5	2	1	0.2	0.1
z	1.65	1.96	2.33	2.58	3.09	3.29

South African Correction to June Deacon's Challenge

You will be pleased to know that we read the ACB News avidly down here. We discuss the Deacon's calculations regularly. We picked up a calculation error on page 11 of the June 2014 ACB News which we thought readers would appreciate. The molecular weight of Lithium Carbonate is 73.89 rather than 66.95 which changes the calculation a little. The formula for Lithium Carbonate is Li2Co3 and not LiCo3 as stated.

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