

Deacon's Challenge

No 186 - Answer

Two solutions (A and B) have the following compositions:

A: 6 g anhydrous sodium dihydrogen orthophosphate in 500 mL water

B: 7.1 g anhydrous disodium hydrogen orthophosphate in 500 mL water

- a) 50 mL of A is mixed with 50 mL B and the measured pH is 6.82. Calculate the pK_{a_2} .
b) 60 mL of A is mixed with 40 mL B. Calculate the expected pH.

First calculate the molar concentrations of phosphate in each of solutions A and B:

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

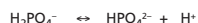
For A: $\text{MW NaH}_2\text{PO}_4 = 23 + (2 \times 1) + 31 + (4 \times 16) = 23 + 2 + 31 + 64 = 120$

$$\text{Concentration (mol/L)} = \frac{2 \times 6}{120} = 0.1 \text{ mol/L}$$

For B: $\text{MW Na}_2\text{HPO}_4 = (2 \times 23) + 1 + 31 + (4 \times 16) = 46 + 1 + 31 + 64 = 142$

$$\text{Concentration (mol/L)} = \frac{2 \times 7.1}{142} = 0.1 \text{ mol/L}$$

- a) If solutions A and B are mixed in equal proportions then the concentration of each phosphate species will become 0.05 mol/L. Therefore the pK_{a_2} will be equal to the pH:
The dissociation to be considered is:



and the Henderson-Hasselbalch equation is:

$$\text{pH} = \text{p}K_{a_2} + \log_{10} \frac{[\text{Na}_2\text{HPO}_4]}{[\text{NaH}_2\text{PO}_4]}$$

Which can be re-arranged to:

$$\text{p}K_{a_2} = \text{pH} - \log_{10} \frac{[\text{Na}_2\text{HPO}_4]}{[\text{NaH}_2\text{PO}_4]}$$

Substitute for pH and both phosphate concentrations and solve for pK_{a_2} :

$$\text{p}K_{a_2} = 6.82 - \log_{10} \frac{0.05}{0.05} = 6.82 - \log_{10} 1 = 6.82 - 0 = 6.82$$

- b) Calculate the final concentrations for each phosphate species when 60 mL of A is mixed with 40 mL of B:

$$[\text{NaH}_2\text{PO}_4] = 0.1 \times \frac{60}{100} = 0.06 \text{ mol/L}$$

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$$[\text{Na}_2\text{HPO}_4] = 0.1 \times \frac{40}{100} = 0.04 \text{ mol/L}$$

Substitute these values into the Henderson-Hasselbalch equation and solve for pH:

$$\text{pH} = 6.82 + \log_{10} \frac{0.04}{0.06}$$

$$\text{pH} = 6.82 + \log_{10} 0.6667$$

$$\text{pH} = 6.82 + (-0.18)$$

$$\text{pH} = 6.64$$

Question 187

A solution contains 250 mg NADH disodium salt (formula $\text{C}_{21}\text{H}_{27}\text{N}_7\text{O}_{14}\text{P}_2\text{Na}_2$) per litre. A 1 in 5 dilution transmits 36% of incident light at 340 nm (versus an appropriate blank) in a cell with 1 cm path length.

- a) Calculate the molar absorptivity of NADH.
b) How much of the original solution will be needed to prepare 1 L of a solution with an absorbance at 340 nm of 0.5 when measured in a cell with a path length of 0.5 cm?



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