

### Problem 8-13 Buffers

0.096 mol of sodium acetate was dissolved in v 800 cm<sup>3</sup> of acetic acid solution of concentration 0.1 mol dm<sup>-3</sup>.

- What is pH of this buffer solution?
- What change in pH will cause an addition of 2 cm<sup>3</sup> HCl solution of concentration 4 mol dm<sup>-3</sup> (neglect the mixing change in volume)?
- What change in pH will occur if you dissolve 8 mmol of NaOH in this buffer solution?

[(a) pH = 4.838 ; (b) ΔpH = 0.078 ; (c) ΔpH = -0.046]

**Solution:**



$$c_{\text{HAc}} = 0.1 \text{ mol dm}^{-3}$$

$$c_{\text{NaAc}} = c_{\text{Ac}^-} = \frac{0.096}{0.800} = 0.12 \text{ mol dm}^{-3}$$

( $c_{\text{Ac}^-}$  which is formed by dissociation of the acid is negligible due to very small value of the dissociation constant)

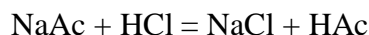
$$c_{\text{H}^+} = K_{\text{HAc}} \cdot \frac{c_{\text{HAc}}}{c_{\text{Ac}^-}} = 1.78 \cdot 10^{-5} \cdot \frac{0.1}{0.12} = 1.4833 \cdot 10^{-5} \text{ mol dm}^{-3}$$

$$\text{pH} = -\log(1.4833 \cdot 10^{-5}) = 4.8277$$

- (b)  $V_{\text{HCl}} = 2 \text{ cm}^3$ ,  $(c_{\text{HCl}})_0 = 4 \text{ mol dm}^{-3}$   
 $V_{\text{solution}} = 800 \text{ cm}^3$

$$c_{\text{HCl, solution}} = \frac{(c_{\text{HCl}})_0 \cdot V_{\text{HCl}}}{V_{\text{solution}}} = \frac{4 \cdot 2}{800} = 0.01 \text{ mol dm}^{-3}$$

On addition of the strong acid a reaction



will occur and 0.01 mol dm<sup>-3</sup> of acetate converts to 0.01 mol dm<sup>-3</sup> of acid HAc

New balance:

$$c_{\text{HAc}} = 0.1 + 0.01 = 0.11 \text{ mol dm}^{-3}$$

$$c_{\text{Ac}^-} = 0.12 - 0.01 = 0.11$$

$$c_{\text{H}^+} = K_{\text{HAc}} \cdot \frac{c_{\text{HAc}}}{c_{\text{Ac}^-}} = 1.78 \cdot 10^{-5} \cdot \frac{0.11}{0.11} = 1.78 \cdot 10^{-5} \text{ mol dm}^{-3}$$

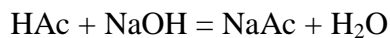
$$\text{pH} = -\log(1.78 \cdot 10^{-5}) = 4.7506$$

The change in pH:  $\Delta\text{pH} = 4.8277 - 4.7506 = 0.0771$

- (c)  $n_{\text{NaOH}} = 8 \cdot 10^{-3} \text{ mol NaOH}$ ,  $V_{\text{solution}} = 800 \text{ cm}^3$

$$c_{\text{NaOH}} = \frac{8 \cdot 10^{-3}}{0.800} = 0.01 \text{ mol dm}^{-3}$$

On addition of the strong base a reaction



will occur and 0.01 mol dm<sup>-3</sup> of acid HAc converts to 0.01 mol dm<sup>-3</sup> of salt NaAc

New balance:

$$c_{\text{HAc}} = 0.1 - 0.01 = 0.09 \text{ mol dm}^{-3}$$

$$c_{\text{Ac}^-} = 0.12 + 0.01 = 0.13$$

$$c_{\text{H}^+} = K_{\text{HAc}} \cdot \frac{c_{\text{HAc}}}{c_{\text{Ac}^-}} = 1.78 \cdot 10^{-5} \cdot \frac{0.09}{0.13} = 1.2369 \cdot 10^{-5} \text{ mol dm}^{-3}$$

$$\text{pH} = -\log(1.2369 \cdot 10^{-5}) = 4.9071$$

The change in pH:  $\Delta\text{pH} = 4.8277 - 4.9071 = -0.0794$