Electronic Supplementary Material (ESI) for Lab on a Chip

SUPPORTING INFORMATION

A microfluidic platform for university-level analytical chemistry laboratories

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SUPPORTING INFORMATION

Determining pH versus Q_B/Q_T for titration of a strong acid and strong base

Case 1: $Q_{KOH}/Q_T < Q_{KOH,e}/Q_T$

Here we consider the acid solution (titrand) as being incompletely titrated by the base (titrant).

Therefore, the remaining $[H^+]$ is calculated as:

$$[H^+] = [HCl]\times Q_{HCl}/Q_T - [KOH]\times Q_{KOH}/Q_T$$

Case 2: $Q_{KOH}/Q_T > Q_{KOH,e}/Q_T$

Here we consider the base solution (titrand) as being incompletely titrated by the acid (titrant).

Therefore, the remaining $[OH^-]$ is calculated as:

$$[OH^-] = [KOH]\times Q_{KOH}/Q_T - [HCl]\times Q_{HCl}/Q_T$$

For case two, the concentration of H^+ is given by $[H^+] = K_w/[OH^-]$.

Titration of a weak acid with a strong base

Goal: find $Q_{B,pKa}/Q_T$ (i.e., Q_B/Q_T that results in pH = pK_a)

As described in Equation (11) from the main text, pH is given by the Henderson-Hasselbalch equation.

$$pH = pK_a + \log\left(\frac{[B]_i \times \frac{Q_B}{Q_T}}{[A]_i \times \frac{Q_A}{Q_T} - [B]_i \times \frac{Q_B}{Q_T}}\right)$$

pH = pK_a when the following condition is true:

$$[B]_i \times \frac{Q_B}{Q_T} = [A]_i \times \frac{Q_A}{Q_T} - [B]_i \times \frac{Q_B}{Q_T}$$

$$2[B]_i \times \frac{Q_B}{Q_T} = [A]_i \times \frac{Q_A}{Q_T}$$

Since $Q_B + Q_A = Q_T$, then $Q_A = Q_T - Q_B$

Therefore,

$$2[B]_i \times Q_B = [A]_i \times (Q_T - Q_B)$$

$$2[B]_i \times Q_B = Q_T[A]_i - [A]_i \times Q_B$$

$$Q_B(2[B]_i + [A]_i) = Q_T[A]_i$$

Therefore, the above derivation of the flow rate of the base which is required to achieve a condition where the pH = pK_a, can be summarized in a general format as follows:

$$Q_{B,pKa}/Q_T = \frac{[A]_i}{2[B]_i + [A]_i} \quad \text{(S1)}$$

For the system demonstrated in this work, $[KOH]_i = [CH_3COOH]_i = 1M$, $Q_T = 2$ mL h^{-1}.

Therefore, Eq. 11 reduces to

$$pH = pK_a + \log\left(\frac{\frac{Q_{KOH}}{Q_T}}{\frac{Q_{CH_3COOH}}{Q_T} - \frac{Q_{KOH}}{Q_T}}\right)$$

And $pH = pK_a$ when the following holds true:

$$\frac{Q_{KOH}}{Q_T} = \frac{Q_{CH_3COOH}}{Q_T} - \frac{Q_{KOH}}{Q_T}$$

$$2Q_{KOH} = Q_{CH3COOH}$$

Since $Q_{KOH} + Q_{CH3COOH} = 2$, it follows that $Q_{CH3COOH} = 2 - Q_{KOH}$

Therefore, $2Q_{KOH} = 2 - Q_{KOH}$, and $Q_{KOH} = 2/3$ mL h^{-1}, $Q_{CH3COOH} = 4/3$ mL h^{-1}