Resource 1 – Chapter 8

Deriving the Henderson–Hasselbalch equation

The Henderson–Hasselbalch equation is used to calculate the pH of a buffer. Here the derivation for the equation is given, based on a buffer made from solutions of acid HA and base A^-.

For acid HA:

$$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$$

$$K_a = \frac{[A^-(aq)][H^+(aq)]}{[HA(aq)]}$$

When preparing a buffer from acid HA and base A^-, we can make the approximation that $[A^-(aq)]$ and [HA] at equilibrium are the same as the initial concentrations. We can therefore write:

$$K_a = \frac{[salt][H^+(aq)]}{[acid]}$$

Taking $-\log_{10}$ of both sides gives:

$$-\log_{10}K_a = -\log_{10}[salt] - \log_{10}[acid] + \log_{10}[H^+]$$

$$pK_a = -\log_{10}[salt] - \log_{10}[acid] + pH$$

which rearranges to the Henderson–Hasselbalch equation:

$$pH = pK_a + \log_{10}\frac{[salt]}{[acid]}$$