

Problem 8-11 Balance of simultaneous equilibria in electrolyte solutions

What is pH of the solution containing in 2 dm³ 0.01 mol HCl and 0.04 mol NH₄Cl at the temperature of 25 °C? Acidity constant of NH₃ has the value of $K_a = 5.6 \cdot 10^{-10}$, ionic product of water $K_w = 1.008 \cdot 10^{-14}$.

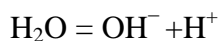
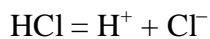
[pH = 2 (the solution is not a buffer)]

Solution:



conversion x

$$K_a = \frac{a_{\text{NH}_3} \cdot a_{\text{H}^+}}{a_{\text{NH}_4^+}} = 5.6 \cdot 10^{-10}$$



conversion y

$$K_w = a_{\text{OH}^-} \cdot a_{\text{H}^+} = 1.008 \cdot 10^{-14}$$

Balance: $\text{NH}_4\text{Cl} = S$,

$$c_{S0} = 0.1 \text{ mol dm}^{-3}$$

$$c_{A0} = 0.0005 \text{ mol dm}^{-3}$$

$$c(\text{NH}_4^+) = c_{S0} - x$$

$$c(\text{NH}_3) = x$$

$$c(\text{H}^+) = c_{\text{HCl}} + x + y \quad , \quad x + y \ll c_{\text{HCl}} \quad (K_a \text{ i } K_w \text{ are very small})$$

$$c(\text{OH}^-) = y$$

$$c_{\text{H}^+} = c_{\text{HCl}} = 0.01 \text{ mol dm}^{-3}$$

$$\text{pH} = -\log c_{\text{H}^+} = -\log 0.01 = 2$$

This solution is not a buffer.