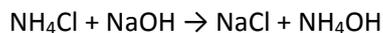## Question
500 mL of a solution containing 1.5 M $NH_4Cl_{(aq)}$ is mixed with 500 mL of a solution containing 0.5 M of $NaOH_{(aq)}$. What is the pH of the final solution ($K_b(NH_3)=1.8 \cdot 10^{-5}$)?

Solution
$NH_4Cl + NaOH \rightarrow NaCl + NH_4OH$

Initially:
$n(NH_4Cl)_{init.} = V(NH_4Cl) \cdot C(NH_4Cl) = 0.5 \cdot 1.5 = 0.75$ mol
$n(NaOH)_{init.} = V(NaOH) \cdot C(NaOH) = 0.5 \cdot 0.5 = 0.25$ mol

After mixing:
$n(NaOH) = 0$ mol – it has been completely reacted.
$n(NH_4Cl)_{reacted} = n(NaOH)_{init.} = 0.25$ mol
$n(NH_4Cl) = n(NH_4Cl)_{init.} - n(NH_4Cl)_{reacted} = 0.75 - 0.25 = 0.50$ mol
$n(NH_4OH) = n(NH_4Cl)_{reacted} = 0.25$ mol
$n(NaCl) = 0.25$ mol, but it has no effect on the final solution.

The final solution volume $V = V(NH_4Cl) + V(NaOH) = 0.5 + 0.5 = 1.0$ L

The final solution is an ammonia buffer solution. The ammonia buffer solution pH is calculated by the formula

$$pH = 14 - pK_b - lg\frac{C_{NH_4^+}}{C_{NH_3}}$$

$$C_{NH_4^+} = \frac{n(NH_4Cl)}{V} = \frac{0.5}{1.0} = 0.5 \; mol/L$$

$$C_{NH_3} = \frac{n(NH_4OH)}{V} = \frac{0.25}{1.0} = 0.25 \; mol/L$$

$$pK_b = -lgK_b$$

Now we can calculate the pH of final solution

$$pH = 14 - pK_b - lg\frac{C_{NH_4^+}}{C_{NH_3}} = 14 + lg1.8 \cdot 10^{-5} - lg\frac{0.5}{0.25} = 8.95$$

Answer: pH = 8.95