40 ml of 0.1M ammonia solution is mixed with 20 ml of 0.1M HCl. What is the pH of the mixture? ($pK_b$ of ammonia solution is 4.74).

**Solution**: Ammonia reacts with hydrochloric acid, forming a salt – ammonium chloride:

$$NH_4OH + HCl \rightarrow NH_4Cl + H_2O$$

Amount of substance of ammonia is $n(NH_4OH) = C(NH_4OH)\cdot V(NH_4OH) = 0.1\cdot 40 = 4$ mol.

Amount of substance of hydrochloric acid is $n(HCl) = C(HCl)\cdot V(HCl) = 0.1\cdot 20 = 2$ mol.

As you see, hydrochloric acid is in deficiency, and it will completely react with ammonia. Then, excess of ammonia, which stays unreacted is $n'(NH_4OH) = n(NH_4OH) - n(HCl) = 4 - 2 = 2$ mol.

And amount of substance of obtained ammonium chloride is equal to the amount of substance of reacted hydrochloric acid, $n(NH_4Cl) = 2$ mol.

We obtain the solution of the weak base and salt of this base and strong acid, it is the buffer solution.

According to the Henderson-Hasselbach equation, pH of such buffer solution can be calculated as: $pH = 14 - pK_b - \log\left(\frac{[B^+]}{[BOH]}\right)$, where [BOH] is the molar concentration of the weak base in the solution, $[B^+]$ is the molar concentration of the base's anion in the solution (it is equal to the concentration of salt).

In our case, concentrations of the weak base and its salt are equal, because their amounts of substance are equal, then: $\frac{[B^+]}{[BOH]} = 1,\ \ pH = 14 - 4.74 - \log 1 = 9.26$

**Answer**: 9.26.