- A dilute solution of ammonia has a pH of 10.54. Calculate what amount of HCl(g) must be added to 1.0 L of this solution to give a final pH of 8.46. The pK_a of NH_4^+ is 9.24.

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In the initial solution, pH = 10.54 so pOH = 14.00 – 10.54 = 3.46 and:

$[OH^-(aq)] = 10^{-3.46} = 0.000347$ M

This is formed by the reaction below.

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

Hence, $[NH_4^+(aq)] = [OH^-(aq)] = 0.000347$ M. This reaction corresponds to K_b for NH_3. As K_a for NH_4^+ = 9.24, K_b = 14.00 – 9.24 = 4.76 and

$$K_b = \frac{[NH_4^+(aq)][OH^-(aq)]}{[NH_3(aq)]} = \frac{(10^{-3.46})(10^{-3.46})}{[NH_3(aq)]} = 10^{-4.76}$$

Hence, $[NH_3(aq)] = 10^{-2.16} = 0.00692$ M

This reacts with the added HCl(g):

	$H^+(aq)$	$NH_3(aq)$	$\rightleftharpoons$	$NH_4^+(aq)$
initial	x	**0.00692**		**0.000347**
final	**0**	**0.00692 – x**		**0.000347 + x**

At the final pH of 8.46, the Henderson-Hasselbalch equation can be used:

$$pH = pK_a + \log\frac{[NH_3(aq)]}{[NH_4^+(aq)]}$$

$$8.46 = 9.24 + \log\left(\frac{0.00692 - x}{0.000347 + x}\right)$$

Solving this gives x = 0.0059 mol.

Answer: **0.0059 mol**