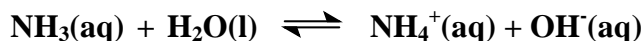


- A dilute solution of ammonia has a pH of 10.54. Calculate what amount of HCl(g) must be added to 1.0 L of this solution to give a final pH of 8.46. The  $pK_a$  of  $NH_4^+$  is 9.24.

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

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

This is formed by the reaction below.



Hence,  $[NH_4^+(aq)] = [OH^-(aq)] = 0.000347 \text{ M}$ . 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,  $[NH_3(aq)] = 10^{-2.16} = 0.00692 \text{ M}$

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  $x = 0.0059 \text{ mol}$ .

Answer: **0.0059 mol**