CHAPTER 17	Calculating K_b for a Weak Base	BLM 17.3.3
OVERHEAD		

Problem

One of the uses for aniline, $C_6H_5NH_2(\ell)$, is in the manufacture of dyes. Aniline is soluble in water and acts as a weak base. When a solution containing 5.0 g/L of aniline was prepared, the pH was found to be 8.68. Calculate the base ionization constant for aniline.

What Is Required?

You need to find K_b for aniline.

What Is Given?

You have the following data:
The formula for aniline is $C_6H_5NH_2(\ell)$
The solution contains 5.0 g/L $C_6H_5NH_2(aq)$
pH = 8.68

Plan Your Strategy

Step 1 Calculate the molar concentration of the solution using the molar mass of aniline and the mass of aniline dissolved in one litre of solution.

Step 2 Calculate the hydroxide ion concentration using the following:
pH + pOH = 14.0
$[OH^-(aq)] = 10^{-pOH}$

Step 3 Write the equation for the ionization equilibrium of aniline in water. Then set up an ICE table.

MathTip

Remember, in the ICE table $[H_2O(\ell)]$ is left blank. Compared with the equilibrium concentration of hydroxide ion, 1.0×10^{-7} is not significant in the problems you will solve. To show this, write ~0 (“almost zero”) in the ICE table for the initial $[OH^-(aq)]$.

Step 4 Write the expression for the base ionization constant. Substitute equilibrium terms into the expression and calculate K_b.

Calculating K_b for a Weak Base

Act on Your Strategy

Step 1 Calculate the molar concentration of the solution.

Molar mass of aniline, $C_6H_5NH_2(\ell)$, = 93.12 g/mol

$$[C_6H_5NH_2(aq)] = \frac{5.0\,\frac{\cancel{g}}{L}}{93.12\,\frac{\cancel{g}}{mol}}$$

$$= 0.0537\,\frac{mol}{L}$$

Step 2 Calculate $[OH^-(aq)]$.

$$pOH = 14.0 - 8.68$$
$$= 5.32$$
$$[OH^-(aq)] = 10^{-5.32}$$
$$= 4.79 \times 10^{-6}$$

Step 3 Use the equation for the ionization equilibrium of aniline in water to set up an ICE table.

$$C_6H_5NH_2(aq) + H_2O(\ell) \leftrightarrow C_6H_5NH_3^+(aq) + OH^-(aq)$$

	$[C_6H_5NH_2(aq)]$ (mol/L)	$[H_2O(\ell)]$ (mol/L)	$[C_6H_5NH_3^+(aq)]$ (mol/L)	$[OH^-(aq)]$ (mol/L)
Initial	0.0537		0	~0
Change	-4.79×10^{-6}		$+4.79 \times 10^{-6}$	$+4.79 \times 10^{-6}$
Equilibrium	$(0.0537 - 4.79 \times 10^{-6})$		$+4.79 \times 10^{-6}$	$+4.79 \times 10^{-6}$

Step 4 Write the expression for K_b. Substitute equilibrium terms into the expression.

$$K_b = \frac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]}$$

$$= \frac{(4.79\times10^{-6})(4.79\times10^{-6})}{0.0537}$$

$$= 4.3\times10^{-10}$$

Check Your Solution

The value for K_b is reasonable for a weak base. The answer has the correct number of significant digits (two).