CHAPTER 17	Calculating the pH of a Weak Base	BLM 17.3.5
OVERHEAD		

Problem

The characteristic bitter taste of tonic water is due to the addition of quinine. Quinine, $C_{20}H_{24}N_2O_2(s)$, is a naturally occurring, white crystalline compound. It is also used to treat malaria. The base ionization constant, K_b, for quinine is 3.3×10^{-6}. What is the hydroxide ion concentration and pH of a 3.6×10^{-3} mol/L solution of quinine?

What Is Required?

You need to find $[OH^-(aq)]$ and pH.

What Is Given?

$K_b = 3.3 \times 10^{-6}$
Concentration of quinine = 3.6×10^{-3} mol/L

Plan Your Strategy

Step 1 Let Q represent the formula of quinine. Write the equation for quinine acting as a base in water. Then set up an ICE table.

Step 2 Check the value of $\dfrac{[Q]}{K_b}$ to make sure the amount of quinine that ionizes is not significant compared with the initial concentration.

Step 3 Write the expression for the base ionization constant. Substitute equilibrium terms into the equation.

Step 4 Solve the equation for x.

Step 5 $pOH = -\log [OH^-(aq)]$
$pH = 14.00 - pOH$

Calculating the pH of a Weak Base (continued)

Act on Your Strategy

Step 1

$$Q(aq) + H_2O(\ell) \leftrightarrow HQ^+(aq) + OH^-(aq)$$

	[Q(aq)] (mol/L)	$[H_2O(\ell)]$ (mol/L)	$[HQ^+(aq)]$ (mol/L)	$[OH^-(aq)]$ (mol/L)
Initial	3.6×10^{-3}		0	~0
Change	$-x$		$+x$	$+x$
Equilibrium	$(3.6 \times 10^{-3} - x)$		x	x

Step 2 $\frac{[Q]}{K_b} = \frac{3.6\times10^{-3}}{3.3\times10^{-6}} = 1.1\times10^3$

Since this value is greater than 1000, the amount that ionizes is not significant compared with the initial concentration of the quinine. Thus, $(3.6 \times 10^{-3} - x)$ is approximately 3.6×10^{-3}.

Step 3

$$K_b = \frac{[HQ^+][OH^-]}{[Q]}$$

$$3.3\times10^{-6} = \frac{(x)(x)}{3.6\times10^{-3}}$$

Step 4

$$3.3\times10^{-6} = \frac{x^2}{3.6\times10^{-3}}$$

$$x^2 = 1.188\times10^{-8}$$

$$x = 1.09\times10^{-4}$$

$$x \approx 1.1\times10^{-4}\ \frac{\text{mol}}{\text{L}} = [OH^-(aq)]$$

Step 5

$\text{pOH} = -\log 1.09 \times 10^{-4}$
$= 3.96$
$\text{pH} = 14.00 - \text{pOH}$
$\text{pH} = 10.04$

Check Your Solution

The pH of the solution is greater than 7, as expected for a basic solution. The answer has the correct number of significant digits (two).

MathTip

If an acid or a base has a complex molecular formula, you can represent the formula using a shortened notation, such as Q for quinine. Remember that a Brønsted-Lowry acid always provides a proton to water, and a Brønsted-Lowry base always accepts a proton from water.