

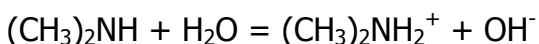
Calculating the pH of weak bases:

Problem: Dimethylamine $(\text{CH}_3)_2\text{NH}$, a key intermediate in detergent manufacture, has a K_b of 5.9×10^{-4} . What is the pH of a 1.5 mol L^{-1} solution of dimethylamine?

Plan: We know; The initial concentration of the base (it is 1.5 mol L^{-1})
 The K_b of the base (it is 5.9×10^{-4})

We want to calculate the pH of the solution.

The reaction between dimethylamine and water is:



We can write the K_b expression as: $K_b = [(\text{CH}_3)_2\text{NH}_2^+][\text{OH}^-] / [(\text{CH}_3)_2\text{NH}]$

$$[\text{OH}^-] \text{ from base} = [(\text{CH}_3)_2\text{NH}_2^+] = [\text{OH}^-]$$

Because K_b is small, we can assume that the amount of amine reacting is also small (it's a weak base), so;

$$[(\text{CH}_3)_2\text{NH}]_{\text{initial}} - [(\text{CH}_3)_2\text{NH}]_{\text{reacting}} = [(\text{CH}_3)_2\text{NH}] \approx [(\text{CH}_3)_2\text{NH}]_{\text{initial}}$$

Solution to this Problem:

- **Set up a change table:**

Concentration (mol L^{-1})	$(\text{CH}_3)_2\text{NH}$ (aq)	H_2O (l)	$(\text{CH}_3)_2\text{NH}_2^+$ (aq)	OH^- (aq)
Initial	1.5	-	0	0
Change	- x	-	+ x	+ x
Equilibrium	1.5 - x	-	x	x

Making the assumption;

K_b is small, so $[(\text{CH}_3)_2\text{NH}]_{\text{initial}} \approx [(\text{CH}_3)_2\text{NH}]$; thus, $1.5 \text{ mol L}^{-1} - x \approx 1.5 \text{ mol L}^{-1}$

Substituting this into the K_b expression and solving for x;

$$K_b = [(\text{CH}_3)_2\text{NH}_2^+][\text{OH}^-] / [(\text{CH}_3)_2\text{NH}] = 5.9 \times 10^{-4} \approx x^2 / 1.5 \text{ mol L}^{-1}$$

$$x = [\text{OH}^-] \approx 3.0 \times 10^{-2}$$

Calculating the pH:

$$[\text{H}^+] = K_w / [\text{OH}^-] = 1.0 \times 10^{-14} / 3.0 \times 10^{-2} = 3.3 \times 10^{-13} \text{ mol L}^{-1}$$

$$\begin{aligned} \text{pH} &= -\text{Log}_{10} [\text{H}^+] \\ &= -\text{Log}_{10} [3.3 \times 10^{-13} \text{ mol L}^{-1}] \end{aligned}$$

pH = 12.48

Class Practice Problems

- a.) Pyridine ($\text{C}_5\text{H}_5\text{N}$) plays a major role in organic syntheses as a solvent and also as a base. It has a pK_b of 8.77. What is the pH of a 0.10 mol L^{-1} pyridine solution?

- b.) Codeine ($\text{C}_{18}\text{H}_{21}\text{NO}_3$) is a narcotic pain reliever that forms a salt with HCl (codeine hydrochloride). What is the pH of 0.050 mol L^{-1} codeine hydrochloride? The pK_b of codeine is 5.80.