

CURIOUS PH PROBLEM

CHEM 251 SDSU

CURIOUS PROBLEM

What is the pH of a solution of a solution with 7.93×10^{-8} M NaOH?

SIMPLE PH PROBLEM?

What is the pH of a solution of NaOH with a concentration of $7.93 \times 10^{-8} \text{ M}$?

Standard approach:

$$[\text{NaOH}] = 7.93 \times 10^{-8} \text{ M} \quad \text{pH}=?$$

$$14 = \text{pH} + \text{pOH}$$

$$\text{pOH} = -\log[\text{OH}^-]$$

$$\text{pOH} = -\log[7.93 \times 10^{-8}] = 7.10$$

$$\text{pH} = 14 - 7.10$$

$$\text{pH} = 6.90 \quad \dots \text{ so NaOH is an acid???$$

What went wrong with this calculation?

We neglected to account for the contribution of water (dissociation into H^+ and OH^-) and that contribution to the pH.

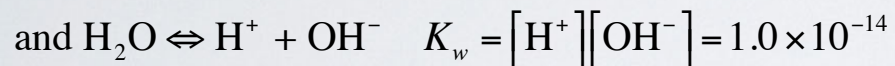
$$K_w = [\text{H}^+][\text{OH}^-] = 1.0 \times 10^{-14}$$

NOT SO SIMPLE PH PROBLEM

What is the pH of a solution of NaOH with a concentration of $7.93 \times 10^{-8} \text{ M}$?

$$[\text{NaOH}] = 7.93 \times 10^{-8} \text{ M} \quad \text{pH} = ?$$

Equilibria:



$$[\text{Na}^+] = 7.93 \times 10^{-8} \text{ M}$$

$$[\text{H}^+] = x$$

$$[\text{OH}^-] = 7.93 \times 10^{-8} \text{ M} + x$$

$$K_w = [\text{H}^+][\text{OH}^-] = (x)(7.93 \times 10^{-8} + x) = 1.0 \times 10^{-14}$$

$$1.0 \times 10^{-14} = x^2 + 7.93 \times 10^{-8}(x)$$

$$0 = x^2 + 7.93 \times 10^{-8}(x) - 1.0 \times 10^{-14}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-7.93 \times 10^{-8} + \sqrt{(7.93 \times 10^{-8})^2 - 4(1)(-1.0 \times 10^{-14})}}{2(1)}$$

$$x = [\text{H}^+] = 6.79 \times 10^{-8} \text{ M} \quad \text{pH} = -\log(6.79 \times 10^{-8} \text{ M}) = 7.17$$

First identify the relevant equilibria and see how they are related, in this case OH^- is in common in both reactions.

Then solve for the common unknown value (x).

CONTRIBUTION OF WATER

- The autoprotolysis of water will contribute to the pH of a solution in select cases
- The concentration of the acid/base determines the influence:
 - $[H^+]$ or $[OH^-] \geq 10^{-6}$ water does not contribute
 - $[H^+]$ or $[OH^-] \leq 10^{-8}$ solution is pH 7
 - $10^{-6} \geq [H^+]$ or $[OH^-] \geq 10^{-8}$ autoprotolysis is important