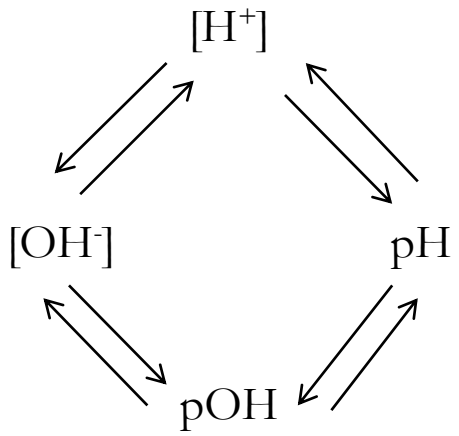
Solving pH, K_A and K_B Problems

A. Solving pH problems:



The above diagram indicates that if you know the value of one of the components (OH^-, H^+, pOH, pH), the value of the component on either side can be determined. For example, if you know the value of pOH, the value of pH or OH^- can be determined. The value of H^+ *cannot* be determined directly. The value of either pH or OH^- must first be determined and in a second step, the value of H^+ can be determined.

The following equations are important in solving pH problems.

1. pH + pOH = 14

2. $[H^+][OH^-] = 1 \times 10^{-14} = K_w$ (self-ionization constant of water)

3. pH = - Log $[H^+]$

4. pOH = - Log $[OH^-]$

5. $[H^+] = 10^{-pH}$

6. $[OH^-] = 10^{-pOH}$

To solve, follow these steps:

1. Write down all the pertinent information. Identify what is to be solved for.

2. Check the diagram to determine if the information can be determined directly, the unknown value is adjacent to the known value. If not, use the 2 step process to determine value between the known and unknown values.

3. Identify equations that solve for the desired unknown value(s).

4. Solve either single step or 2 step process.

Examples:

1. If $[H^+] = 3.2 \times 10^{-5}$mol/L, what are the pH and pOH?

Based on the diagram there are two paths to follow. Path I, solve for $[OH^-]$ then pOH, or Path 2, solve for pH then pOH. The solutions will be identical. Compare the two paths and note that solving for pH then pOH is a more simple calculation.

Path 1

$[H^+][OH^-] = 1 \times 10^{-14}$

$$[OH^-] = \frac{1 \times 10^{-14}}{3.2 \times 10^{-5}} = 3.125 \times 10^{-10}\text{M}$$

$pOH = -\text{Log}\,[OH^-] = 9.505$

$pH = -\text{Log}\,[H^+] = 4.495$

Path 2

$\underline{pH} = -\text{Log}\,[H^+] = -\text{Log}\,[3.2 \times 10^{-5}] = 4.495$

$pH + pOH = 14$

$\underline{pOH} = 14 - 4.495 = 9.505$

2. What value of $[H^+]$ corresponds to a pH of 8.14?

By observing the diagram, the most direct solution would point to $H^{+.}$

Using equation: $[H^+] = 10^{-pH}$

$[H^+] = 10^{-8.14}$

$[H^+] = 7.2 \times 10^{-9}$M

3. What is the pH of a sodium hydroxide solution in which the hydroxide ion concentration = .0026m? From the diagram, we can choose to solve for the adjacent $[H^+]$ or pOH.

A. Using the $[H^+]$ path, calculate H^+ using the equation $[H^+][OH^-] = 1 \times 10^{-14}$. Then calculate the pH.

$$H^+ = \frac{[1 \times 10^{-14}]}{[.0026\text{m}]} = \frac{[1 \times 10^{-14}]}{2.6 \times 10^{-3}} = 3.84 \times 10^{-12}$$

$pH = -\text{Log}\,[H^+] = -\text{Log}\,[3.84 \times 10^{-12}] = 11.41$

B. Using the [pOH] path, calculate the pOH first, then the value of pH.

$pOH = -\text{Log}\,[OH^-] = -\text{Log}\,(2.6 \times 10^{-3}) = 2.59$

Next, solve for pH, using the value of pOH.

$pOH + pH = 14$

$pH = 14 - pOH$

$pH = 14 - 2.59$

$pH = 11.41$

Examples:

1. Calculate $[H^+][pH][pOH]$ in .0050M HNO_3.

   Answer: $H^+ = .005$ pH = 2.30 pOH = 11.7

2. The molarity of OH^- in the water sample is 1.47×10^{-9}m. What is the pH of the solution?

   Answer: 5.17

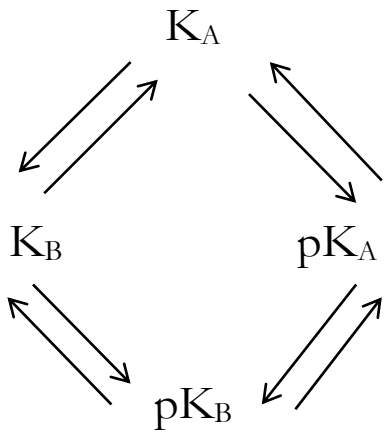
3. What value of $[H^+]$ corresponds to a pH of 8.14?

   Answer: $H^+ = 7.2 \times 10^{-9}$m

B. Solving K_A and K_B Problems

K_A, K_B ionization formulas are analogous to the formulas used to solve Ph problems.

pH	K_A, K_B Ionization Formulas
$pH + pOH = 14$	$pK_A + pK_B = 14$
$[H^+][OH^-] = 1 \times 10^{-14}$	$[K_A][K_B] = 1 \times 10^{-14}$
$pH = -\text{Log}[H^+]$ acid	$pK_A = -\log[K_A]$ acid
$pOH = -\text{Log}[OH^-]$ base	$pK_B = -\log[K_B]$ base
$[H^+] = 10^{-pH}$ acid	$K_A = 10^{-pK_A}$ acid
$[OH^-] = 10^{-pOH}$ base	$K_B = 10^{-pK_B}$ base



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