SIMPLE pH CALCULATIONS: STRONG ELECTROLYTES

- With strong acids and bases, the acid or base completely ionizes in water. So, we only have to worry about the effect of the acid or base on the water equilibrium itself.

- Since the equilibrium constant for the self-ionization of water is so small, the strong acid or base will overpower the hydronium (for acids) or hydroxide (for bases) produced by the water.

$$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^- \; ; \; K_w = 1.0 \times 10^{-14}$$

Consider a solution of 0.025 M nitric acid (a strong acid):

$$HNO_3 + H_2O \longrightarrow H_3O^+ + NO_3^-$$

Assume that all the nitric acid ionizes. Since the presence of hydronium ion will suppress water's ionization, we'll assume all the hydronium in the solution comes from the nitric acid!

So, $[H_3O^+] = [HNO_3]_{nominal} = 0.025\,M$

$pH = -\log_{10}[H_3O^+] = \boxed{1.60}$ *

* For logarithms, the places AFTER the decimal point are significant, while digits in front of the decimal point are not. The digits in front of the decimal in a logarithm are essentially the exponent of the original number!

What would the HYDROXIDE ion concentration be under these conditions?

$$[H_3O^+][OH^-] = 1.0 \times 10^{-14}$$

$$(0.025\,M)[OH^-] = 1.0 \times 10^{-14}$$

$$[OH^-] = 4.0 \times 10^{-13}\,M$$

... this equals the concentration of hydronium that would be produced by the water equilibrium. (Not much!)

Consider a solution of 0.0125 M sodium hydroxide (a strong base):

$$NaOH(aq) \longrightarrow Na^+(aq) + OH^-(aq)$$

Similar to before, we will assume that all the hydroxide ion in solution comes from the sodium hydroxide.

$$[OH^-] = [NaOH]_{nominal} = 0.0125\,\underline{M}\ OH^-$$

We'd like to know pH. First, find pOH:

$$pOH = -\log_{10}(0.0125) = 1.903$$

... and remember that pOH is related to pH:

$$pH + pOH = 14.000$$

$$pH + 1.903 = 14.000$$

$$\boxed{pH = 12.097}$$

Let's check the concentration of HYDRONIUM ion, since that will equal the amount of hydroxide ion produced by water self-ionization. (Remember ... we assumed that this was so small it would be ignorable...)

$$[H_3O^+] = 10^{-pH} = 10^{-12.097}$$

$$[H_3O^+] = 8.00 \times 10^{-13}\,\underline{M}\ H_3O^+$$

... This also equals the amount of hydroxide ion produced by water's self-ionization. And, like in the last example, it's really small.

(A) What is the concentration of hydronium ion in an aqueous solution whose pH is 10.50? (B) What is the hydroxide ion concentration? (C) What molar concentration of sodium hydroxide solution would provide this pH?

A) $pH = 10.50$, $[H_3O^+] = ?$

$10^{-pH} = [H_3O^+]$, So $[H_3O^+] = 10^{-10.50} = \boxed{3.2 \times 10^{-11}\ M}$

B) $[H_3O^+][OH^-] = 1.0 \times 10^{-14}$

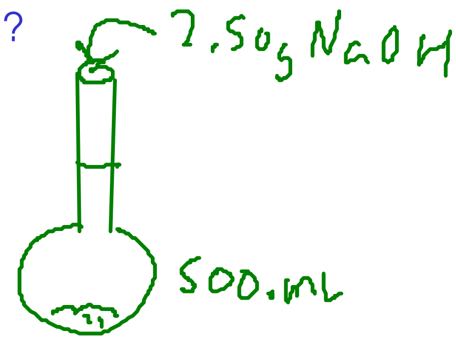
$(3.2 \times 10^{-11})[OH^-] = 1.0 \times 10^{-14}$

$[OH^-] = \boxed{3.2 \times 10^{-4}\ M\ OH^-}$

C) $NaOH \rightarrow Na^+ + OH^-$ (strong base completely ionizes, 1:1 ratio!)

$[NaOH]_{nominal} = \boxed{3.2 \times 10^{-4}\ M}$

What is the pH of a sodium hydroxide solution made from dissolving 2.50 g of sodium hydroxide in enough water to make 500.0 mL of solution?



NaOH : 40.00 g/mol

$$M = \frac{\text{mol NaOH}}{L} \leftarrow 0.5000 L$$

Find concentration of sodium hydroxide:

$$2.50\,g\,NaOH \times \frac{\text{mol NaOH}}{40.00\,g\,NaOH} = 0.0625\text{ mol NaOH}$$

$$M = \frac{\text{mol NaOH}}{L} = \frac{0.0625\text{ mol NaOH}}{0.5000 L} = 0.125\,M\,NaOH$$

Since NaOH is a strong base, we expect it to completely ionize, and since each NaOH produces a single OH-, we expect the nominal NaOH concentration to equal hydroxide ion concentration...

$$NaOH \rightarrow Na^+ + OH^-$$

$$[OH^-] = 0.125 M$$

$$[H_3O^+][OH^-] = 1.0 \times 10^{-14}$$

$$[H_3O^+](0.125) = 1.0 \times 10^{-14}$$

$$[H_3O^+] = 8.0 \times 10^{-14}$$

$$pH = -\log_{10}(8.0 \times 10^{-14})$$

$$= \boxed{13.10}$$