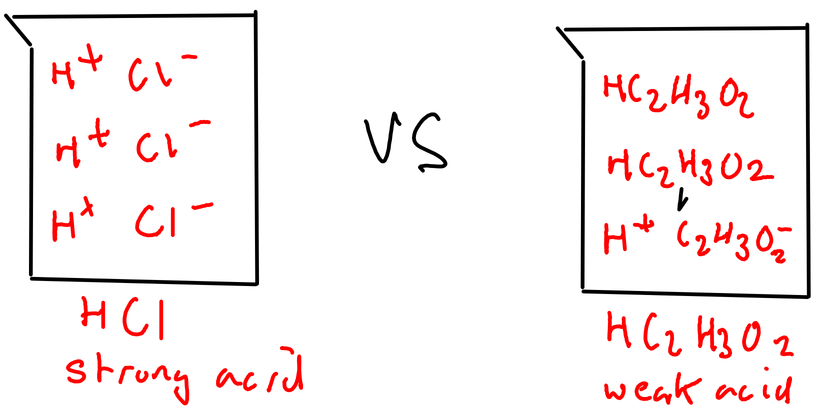
WEAK ELECTROLYTES

- In solutions of weak acids or bases, the UNDISSOCIATED form is present in significantly high concentration.

- The pH of a solution of weak acid will be HIGHER than the pH of a strong acid solution with the same nominal concentration!



Fewer molecules of the weak acid ionize, so the concnetration of hydrogen/hydronium ion is lower, meaning a higher pH!

- The pH of a solution of weak base will be LOWER than the pH of a strong base solution with the same nominal concentration!

Consider a 0.100M solution of nitrous acid, a WEAK ACID (HNO_2)

$$HNO_2 + H_2O \rightleftharpoons H_3O^+ + NO_2^-$$

$$K_a = \frac{[H_3O^+][NO_2^-]}{[HNO_2]} = 4.6 \times 10^{-4}$$

See Appendix H in OpenStax for Ka values

What is the pH of the solution?

We will assume that all the hydronium ion comes from the acid. While nitrous acid is a weak acid, it's a lot stronger that water itself is! Set up an equilibrium chart for the acid.

Species	[Initial]	Δ	[Equilibrium]
H_3O^+	0	+x	x
NO_2^-	0	+x	x
HNO_2	0.100	−x	0.100 − x

Let "x" equal the change in hydronium ion concentration

Plug into the equilibrium expression (Ka):

$$\frac{(x)(x)}{(0.100-x)} = 4.6 \times 10^{-4}$$

$$\frac{x^2}{0.100-x} = 4.6 \times 10^{-4}$$

We need to solve this..

$$\frac{x^2}{0.100-x} = 4.6 \times 10^{-4}$$

Assume x << 0.100,
so 0.100-x = 0.100

$$\frac{x^2}{0.100} = 4.6 \times 10^{-4}$$

$$x^2 = 4.6 \times 10^{-5}$$

$$x = 0.00678233$$

$$[H_3O^+] = 0.00678233\ M$$

$$pH = \boxed{2.17}$$

This is a quadratic, We can solve it with the quadratic equation:

$$ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

When can we assume x is small enough to ignore in the subtraction term?
1) Acid/base equilibrium, some solubility
2) 'x' is defined as representing products
3) The Ka or Kb is 1000x or more smaller than the initial concentrtion of acid or base *

Using this simplifying assumption made this problem easy! But ... how good is this assumption?

Calculating the pH with the quadratic formula results in a pH of 2.18, a difference of only 1 in the uncdertain digit (lower than the margin of error of common pH measurements!)

Compare:

- Weak acid HNO_2 : pH of 0.10 M solution = 2.17

Let's compare the pH of the weak nitrous acid with the pH of a strong acid like nitric acid:

0.10 M HNO_3, what is pH?

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

$$[H_3O^+] = [HNO_3]_{nominal} = 0.10\ M$$

$$pH = 1.00$$

The stronger the acid:

- the lower the pH of a solution of given concentration will be
- the higher the concentration of hydronium ion (when compared to the nominal acid concentration)