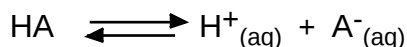


Weak Acids: Weak acids do not dissociate completely in aqueous solutions. They are somewhat stable molecules, you know, maybe with a little covalent character--not completely ionic like strong acids or in the special case of HF, so strongly ionic that water can't pull it apart.

This brings in the idea of equilibrium. Dynamic equilibrium means that there is activity in both the forward and reverse directions of a reaction. For weak acids this means that they partially dissociate and then at equilibrium, the rate at which molecules dissociate equals the rate at which they are reformed.

Take a look at the equilibrium expression, called the **acid dissociation constant** for a generic weak acid.



Again, this is just generic notation for acids, A stands for the weak acid's anion

Acid dissociation Constant: $K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$
(K_a values are tabulated)

Here are some weak acids but again, remember, if its not strong its weak and there are fewer strong acids to remember.

<u>Weak Acid</u>	<u>Ka</u>	<u>Weak Acid</u>	<u>Ka</u>
Acetic acid, $\text{HC}_2\text{H}_3\text{O}_2$	1.8×10^{-5}	Hydrocyanic acid, HCN	4.0×10^{-10}
Benzoic acid, $\text{HC}_7\text{H}_5\text{O}_2$	6.6×10^{-5}	Hydrofluoric acid, HF	6.7×10^{-4}
Chlorous acid, HClO_2	1.1×10^{-2}	Hypobromous acid, HOBr	2.1×10^{-9}
Cyanic acid, HOCN	1.2×10^{-4}	Hypochlorous acid, HOCl	3.2×10^{-8}
Formic acid, HCHO_2	1.8×10^{-4}	Nitrous acid, HNO_2	4.5×10^{-4}
Hydrazoic acid, HN_3	1.9×10^{-5}	Sulfurous acid, H_2SO_4	1.7×10^{-2}
Hydrogen sulfate ion, HSO_4^-	1.0×10^{-2}	Carbonic acid, H_2CO_3	4.4×10^{-7}
Propionic acid, $\text{HC}_3\text{H}_5\text{O}_2$	1.4×10^{-5}	Dihydrogen phosphate ion, H_2PO_4^-	6.2×10^{-8}
Hydrogen sulfide, H_2S	1.0×10^{-7}	Ammonium ion, NH_4^+	5.6×10^{-10}
Hydrogen sulfite ion, HSO_3^-	6.0×10^{-8}	Hydrogen phosphate ion, HPO_4^{2-}	4.5×10^{-13}
Hydrogen carbonate ion, HCO_3^-	4.7×10^{-11}	Hydrogen phosphate ion, HPO_4^{2-}	4.5×10^{-13}

Okay, so dealing with weak acids is just like doing equilibrium problems where you set up the table.

	$\text{HA} \rightleftharpoons \text{H}^+_{(\text{aq})} + \text{A}^-_{(\text{aq})}$		
	$\frac{[\text{HA}]}{[\text{HA}]_0}$	$\frac{[\text{H}^+]}{x}$	$\frac{[\text{A}^-]}{x}$
initial	$[\text{HA}]_0$	-	-
change	$[\text{HA}]_0 - x$	x	x
final	$[\text{HA}]_0 - x$	x	x
$K_a = \frac{[x][x]}{[\text{HA}]_0 - x} = \frac{[x]^2}{[\text{HA}]_0 - x}$			

This is assuming that we start by just dumping some HB into water

If, If, **If**, $K_a < 10^{-5}$ or so, you may avoid the quadratic formula by assuming x will be much, much smaller than $[\text{HA}]_0$ and just solving

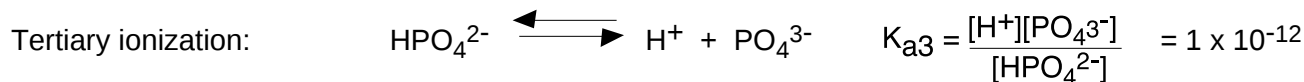
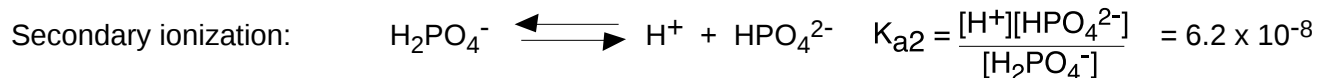
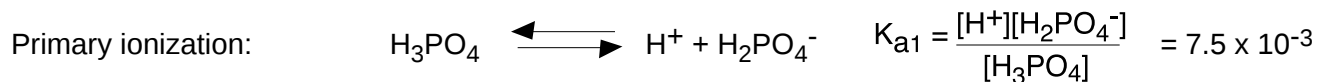
$$K_a = \frac{[x]^2}{[\text{HA}]_0}$$

Make sure K_a is small enough. You are expected to be able to use the quadratic equation

One more formula: Percent Ionization = (moles ionized/total moles) x 100%

Polyprotic Acids <-- Now it's a tough call as to whether polyprotic acids are important enough for their own piece of paper. But you have to know how to deal with them, and it's a little confusing when you have something like H_3PO_4 that has three dissociation reactions, each with their own K_a .

So this is what you've got going on:



Step 1. Look at the primary ionization, use an initial, change, final table and figure out the concentration of species

$$\frac{x^2}{[\text{H}_3\text{PO}_4] - x} = 7.5 \times 10^{-3}$$

Use the quadratic equation to get x. $x = [\text{H}^+] = [\text{H}_2\text{PO}_4^-]$

Step 2. Now use $[\text{H}^+] = [\text{H}_2\text{PO}_4^-] = x$ with the secondary ionization:

$$\frac{x[\text{HPO}_4^{2-}]}{x} = 6.2 \times 10^{-8}$$

Solve for $[\text{HPO}_4^{2-}]$ and

LOOK!

$[\text{HPO}_4^{2-}] = K_{a2}$ if H_3PO_4 is the only source of hydrogen ions in the solution.

Step 3. Again, use the results of the previous steps calculations to do this one $[\text{H}^+]$ from part 1 and $[\text{HPO}_4^{2-}]$ from part 2. (I'll run this example assuming that $[\text{HPO}_4^{2-}] = K_{a2}$)

$$\frac{x[\text{PO}_4^{3-}]}{K_{a2}} = 1 \times 10^{-12} = K_{a3}$$

And notice for this kind of a problem when you just dump H_3PO_4 into water

$$[\text{PO}_4^{3-}] = \frac{K_{a3} K_{a2}}{x}$$

Student Packet: 6.3: Weak Acids: AssessMe questions

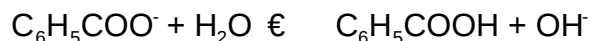
- 1) Which of the statements is a logical consequence of the fact that a 0.10 molar solution of potassium acetate, $\text{KC}_2\text{H}_3\text{O}_2$, is less basic than a 0.10 molar solution of potassium cyanide, KCN?
- A) Hydrocyanic acid (HCN) is a weaker acid than acetic acid.
B) Hydrocyanic acid is less soluble in water than acetic acid.
C) Cyanides are less soluble than acetates.
D) Acetic acid is a weaker acid than hydrocyanic acid.
E) I'm clueless
- 2) Which of the following species is most likely to function both as an acid and as a base?
- A) Cl^- B) H_2O C) NH_4^+ D) H_3O^+ E) I'm clueless
- 3) If 5.00 ml of 15.4 M HNO_3 is diluted to 250 ml, what is the pH of the resulting solution?
- A) 0.51 B) 0.76 C) 1.45 D) 2.89 E) I'm clueless
- 4) What volume of 0.0100 M NaOH must be added to neutralize 1.00 L of 0.0500 M HCl?
- A) 1.00 L B) 5.00 L C) 2.00 L D) 4.00 L E) I'm clueless
- 5) A strong acid is one which
- A) will damage skin independent of the concentration present.
B) dominates the reaction when mixed with a weak acid.
C) is highly dissociated in solution.
D) produces more than one proton per acid molecule.
E) I'm clueless
- 6) A weak acid
- A) does not present a safety hazard and can be allowed to contact the skin.
B) has a proton dissociation equilibrium which favors the reactant.
C) barely reacts when mixed with a base.
D) cannot be used to dissolve a metal.
E) I'm clueless

Student Packet: 6.3: Weak Acids: ShowMe questions

- 1) Sodium benzoate, $\text{C}_6\text{H}_5\text{COONa}$, is a salt of the weak acid, benzoic acid $\text{C}_6\text{H}_5\text{COOH}$. A 0.10 M solution of sodium benzoate has a pH of 8.60.

a) Calculate the $[\text{OH}^-]$ in the sodium benzoate solution described above.

b) Calculate the value for the equilibrium constant for the rxn:



c) Calculate the acid dissociation constant for benzoic acid.

- 2) Calculate the pH of a 0.60 M solution of HF ($K_a = 6.8 \times 10^{-4}$).

- 3) Calculate the $[\text{OH}^-]$, the percent hydrolysis, and the pH of 0.05 M solution of CH_3COONa ($K_a = 1.8 \times 10^{-5}$).

- 4) Calculate the pH of a solution prepared by mixing 10.0 mL of 0.10 M LiOH and 20.0 mL of 0.50 M $\text{C}_6\text{H}_6\text{COOH}$ ($K_a = 6.7 \times 10^{-5}$).

Student Packet: 6.3: Weak Acids : TestMe questions

- 1) If 1.00 L of 1.00 M CH_3COOH is mixed with 0.25 moles of solid NaOH (assume no volume change), what will be the pH of the resulting solution?
- A) 4.14 B) 4.27 C) 4.74 D) 5.35 E) None of the above
- 2) What is the molarity of CH_3COOH in vinegar containing 4.0% CH_3COOH by mass and having a density of 1.02 g/mL?
- A) 0.50 M B) 0.68 M C) 0.75 M D) 1.36 M E) None of the above
- 3) The pH of a 0.10 M solution of a weak acid is 5.40. What is the K_a of the acid?
- A) 1.6×10^{-10} B) 3.2×10^{-10} C) 1.6×10^{-8} D) 8.0×10^{-8} E) 4.0×10^{-8}
- 4) It is found that 0.200 M solutions of the three salts NaX, NaY, and NaZ have pH's of 7.0, 8.0, and 9.0 respectively. Arrange the acids HX, HY, and HZ in order of increasing strength and determine the K_a for each acid.
- A) $\text{HX} (K_a = 5.0 \times 10^{-14}) < \text{HY} (K_a = 5.0 \times 10^{-12}) < \text{HZ} (K_a = 5.0 \times 10^{-10})$
B) $\text{HX} (K_a = 5.0 \times 10^{-10}) < \text{HY} (K_a = 5.0 \times 10^{-12}) < \text{HZ} (K_a = 5.0 \times 10^{-14})$
C) $\text{HZ} (K_a = 2.0 \times 10^{-1}) < \text{HY} (K_a = 2.0 \times 10^{-3}) < \text{HX} (K_a = 2.0 \times 10^{-5})$
D) $\text{HZ} (K_a = 2.0 \times 10^{-5}) < \text{HY} (K_a = 2.0 \times 10^{-3}) < \text{HX} (K_a = 2.0 \times 10^{-1})$
E) None of the above
- 5) A 0.10 M solution of CH_3COOH is 1.3% ionized. What is the pH of this solution? What is the K_a for the acid?
- A) pH = 1.89, $K_a = 1.9 \times 10^{-3}$
B) pH = 1.89, $K_a = 1.7 \times 10^{-5}$
C) pH = 2.89, $K_a = 1.7 \times 10^{-5}$
D) pH = 3.89, $K_a = 2.0 \times 10^{-7}$
E) None of the above